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THE RELATIONSHIP BETWEEN THE HYDROGEN-ION CONCENTRATION AND THE BACTERIAL CONTENT OF COMMERCIAL MILK

EDWIN W. SCHULTZ, ALBERTA MARX, AND HAROLD J. BEAVER

From the Department of Bacteriology and Experimental Pathology, Stanford University, California

During the summer of 1916 the senior author, while working in the department of pediatrics of the Johns Hopkins University, began studies to determine the relationship between the hydrogen ion concentration and the bacterial count of cows' milk. The work then interrupted has recently been continued. The object of this paper is to present the methods employed and the results thus far obtained.

The hydrogen-ion concentration of fresh cows' milk and also that of sour milk, in other words, the range of acidity, has already been determined by a number of workers. Its pH runs from approximately 6.8, for fresh milk, to 4.6, for completely soured milk. On the basis of these facts standard solutions covering this particular range of acidity were prepared.

PREPARATION OF STANDARDS

The standard solutions are prepared by mixing in certain proportions fifteenth molecular solutions each of acid potassium phosphate and alkaline sodium phosphate. These initial solutions are prepared as follows: (a) Fifteenth molecular solution of acid potassium phosphate is prepared by dissolving 9.078 grams of the pure, recrystallized salt (KH_2PO_4), in distilled water and making it up to 1 liter. (b) Fifteenth molecular solution of alkaline sodium phosphate is prepared by dissolving 11.876 grams of the pure, recrystallized, anhydrous, salt ($Na_2HPO_4 \cdot 2H_2O$) in distilled water and making it up to 1 liter. These solutions

are then mixed in the proportions indicated in the following tabulation:

Tabulation of mixtures

	pH							
	7 0	6 9	6 8	6 7	6 6	6.5	6.4	6.3
Acid potassium phosphate, cc....	37 00	44 00	50 50	56 67	62 67	68 50	73 00	77 50
Alkaline sodium phosphate, cc.. .	63 00	56 00	49 50	43 33	37 33	31 50	27 00	22 50

	pH							
	6 2	6 1	6 0	5.9	5 8	5 7	5.6	5 5
Acid potassium phosphate, cc....	81 25	84 25	87 00	90 00	91 50	93 25	94 75	95 67
Alkaline sodium phosphate, cc. .	18 75	15 75	13 00	10 00	8 50	6 75	5 25	4 33

	pH		
	5 4	5 3	5 2
Acid potassium phosphate, cc...	96 50	97 34	97 75
Alkaline sodium phosphate, cc	3 50	2 66	2 25

From 5.2 to 4 4 Phthalate-NaOH mixtures are employed

	pH				
	5 2	5 0	4 8	4 6	4 4
M/5 KH Phthalate. cc. .. .	50 00	50 00	50 00	50 00	50.00
M/5 NaOH, cc..... .. .	29 95	23 85	17.70	12 15	7 50

Each one of the Phthalate-NaOH mixtures is then diluted to 200 cc. A M/5 KH Phthalate solution contains 40.828 grams of the pure salt in 1 liter. The M/5 should be prepared as free as possible from carbonates.

The standard solutions thus made may be set aside and used as required in the preparation of fresh colorimetric standards to be described presently. All the glass used in the preparation and preservation of the standard solutions should be alkali free, such as Jena, Non-sol, or Pyrex. A crystal or two of thymol should be added to the solutions to prevent the growth of molds.

From the stock solutions a set of standard tubes covering the range from 6.8 to 4.6 is next prepared. A convenient size of tube to use for this purpose is one measuring 10 by 110 mm.

To each tube is added 2 cc. of the standard solution, each tube being carefully labeled with the pH it represents. To the entire series is then added an equal amount of indicator per tube. Two indicators are required to cover the range from 6.8 to 4.6. Brom-thymol blue is used from 6.8 to 6.0 and methyl red from 6.0 to 4.6. Enough of either indicator is added to give the most pronounced color changes in the range for which it is employed, usually one-tenth the volume of the standard solution is sufficient.

PREPARATION OF INDICATOR SOLUTIONS

Brom-thymol blue (dibromthymolsulphonephthalein) is prepared by adding 1 decigram of the powder to 3.2 cc. twentieth normal sodium hydroxide. This is warmed and agitated until the powder goes into solution and sufficient distilled water is added to make 15 cc. This constitutes the stock solution. The test solution is prepared by diluting the stock solution with 30 volumes of distilled water.

Methyl red (orthocarboxybenzeneazodimethylaniline) is prepared by dissolving 1 decigram of the powder in 300 cc. of alcohol and diluting to 500 cc. with distilled water.

PREPARATION OF DIALYSER SACS

To prepare the collodion sacs for dialysing the milk 1 ounce of collodion (Anthony's negative cotton) is dissolved in 500 cc. of a mixture of equal quantities of ether and ethyl alcohol. The solution should stand for several days, at which time the clear supernatent fluid is ready for use. A small test tube (9 by 120 mm.) is filled with the collodion, inverted, and half its contents poured out. The tube is then righted and the collodion allowed to fill the lower half again. It is inverted again and rotated on practically its vertical axis, thereby draining off the excess collodion. The tube is then clamped in an inverted position and allowed to stand until the odor of ether has disappeared. Thereupon it is filled several times with cold water and, after loosening the upper rim with the aid of a knife blade, is removed with gentle traction. The sacs should be preserved by complete immersion in water.

TECHNIC OF THE METHOD

The method of determining the hydrogen-ion concentration of the milk consists of putting about 1 cc. of milk in the sac and lowering it into a test tube of the same diameter as those used for the standards and containing 2 cc. of normal (0.8 per cent) salt solution of a neutral reaction. It requires five minutes for dialysis to take place. The sac is then removed, the same amount of indicator used in the standards is added and thoroughly mixed. The reading is made by comparing the tube with the series of standard tubes until the corresponding color is found. This is done with the aid of a simple comparator having a white glass background and in the presence of good light.

BACTERIAL COUNTS

The bacterial counts were made in accordance with the standard methods set forth by the American Public Health Association in 1916. The milk was plated in each instance immediately after the pH readings were made. The milk used was from a city dairy receiving milk from a number of sources.

RESULTS

The results thus far obtained are given on the following chart. The curve represents the averages of the bacterial counts obtained for each pH from 6.8 to 4.6. More determinations would make it, when considered together with the variations in the counts at a given pH, of greater interest and significance.

DISCUSSION

The results thus far obtained do not permit the drawing of definite conclusions. It is suggestive, however, that at a pH of 6.6 the count begins to run high, averaging 16,000,000; at 6.5 reaching an average of 100,000,000, etc., though at these pH readings the acidity cannot be detected by taste. The acidity is first detectable by taste at about a pH of 6.0.

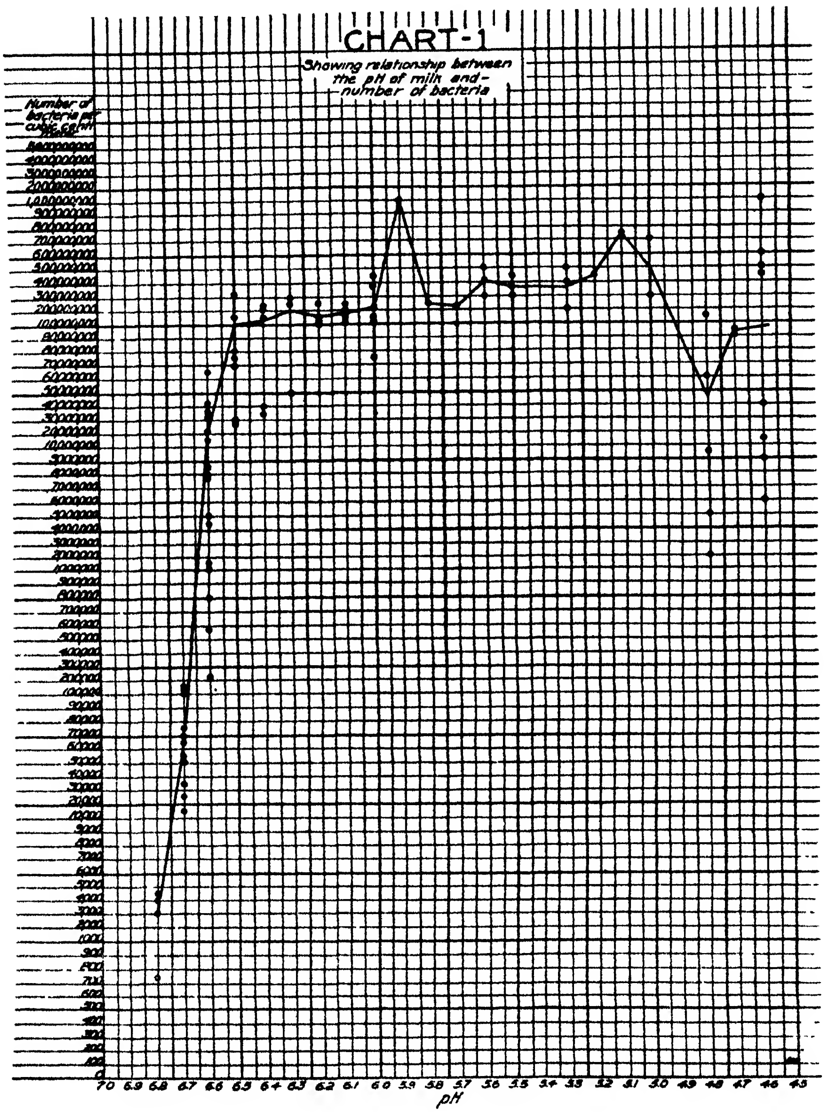
CHART-1
Showing relationship between the pH of milk and number of bacteria
Number of bacteria per cubic centim
pH

From these observations it seems possible that with further determinations a curve of average counts for the range of acidity will be obtained which shall be of value in estimating the number of bacteria in milk, a matter of a few minutes rather than hours required for actually making bacterial counts. This method would therefore be of value in children's institutions and other places where it is of importance to determine immediately the quality of milk before its consumption.

GRADING MILK BY THE ACID TEST: INFLUENCE OF ACIDS IN THE RATION ON THE ACIDITY OF MILK[1]

H. H. SOMMER AND E. B. HART

Department of Dairy Husbandry and Agricultural Chemistry, University of Wisconsin, Madison, Wisconsin

In grading milk by means of the acid test, milk with an acidity of over 0.18 per cent is usually rejected. This practice has revealed a number of herds where the acidity of the fresh milk is greater than 0.18 per cent (1), (2), (3). In some of these cases attempts have been made to lower the acidity by a change in the ration; farmers have been advised to quit feeding silage or bran. This raises two questions:

First: Is milk with a high apparent acidity (over 0.18 per cent) undesirable?

Second: Is the acidity of the milk influenced by acids, organic or inorganic, in the ration?

IS MILK WITH A HIGH APPARENT ACIDITY UNDESIRABLE?

The practice of rejecting milk with a high acidity is used most commonly by condenseries to guard themselves against losses as a result of coagulation on sterilizing the evaporated milk. It is undoubtedly true that milk that has a high acidity due to fermentation will not withstand sterilization; and it is only just that such milk should be rejected. However it does not follow that fresh milk with a high apparent acidity is also undesirable. On the contrary it has been shown by Sommer and Hart that there is no relation between apparent acidity and the heat coagulation under pressure at 136°C. (4).

The following table is reproduced to illustrate this fact.

Out of the 86 samples of fresh milk ranging in acidity from 0.102 to 0.257 per cent, 45 had an acidity of over 0.18 per cent,

[1] Published with the permission of the Director of the Wisconsin Agricultural Experiment Station.

and 41 below 0.18 per cent. Of the 45 samples above 0.18 per cent in acidity, 23 coagulated within twenty minutes when heated under pressure to 136°C.; and of the 41 samples below 0.18 per cent 19 coagulated. This indicates that there is no relation between apparent acidity and coagulation.

The apparent acidity, due to the acid salts and casein, is not an index to the hydrogen ion concentration in the milk. A high apparent acidity does not indicate a high hydrogen ion concentration, and does not in any case cause a sour taste or odor. A sample of milk from the University herd with an acidity of 0.257 per cent did not taste or smell sour. Knowing what the apparent acidity is due to, we do not expect such a sample of milk to taste sour.

TABLE 1

Summary of titratable acidity and coagulation

DATE	TOTAL SAMPLES	ACIDITY ABOVE 0.18 PER CENT		ACIDITY BELOW 0.18 PER CENT	
		Number of samples	Number coagulating in 20 minutes	Number of samples	Number coagulating in 20 minutes
May 8.......	26	15	5	11	6
May 10.......	30	14	7	16	7
May 16......	30	16	11	14	6
Total.......	86	45	23	41	19

We can conclude that milk with a high apparent acidity is not undesirable. There is no justification for rejecting such milk if normal in other respects; and there is no object in attempting to lower the acidity by a change in the ration.

CAN THE ACIDITY OF THE MILK BE INFLUENCED BY ACIDS IN THE RATION?

The question of whether or not the organic acids of silage increase the acidity has been studied, and the results showed clearly that there is no influence (5). However, the inorganic acids, that can not be eliminated from the body by oxidation, might cause a rise in the acidity of the milk. To offer experimental data on this point the following experiment was conducted.

EXPERIMENTAL

Sulphuric acid was added to the ration of a normal healthy cow of the University herd. The titratable acidity, hydrogen ion concentration, and coagulation of the milk, and the reaction of, and distribution of nitrogen in the urine were carefully studied.

The original ration consisted of 30 pounds of silage, mixed hay, and 12 pounds of grain mixture. In feeding the acid, the 30 pounds silage was replaced by a mixture consisting of 15 pounds silage, 6 pounds dry corn stover, and 9 pounds water plus the sulphuric acid. The following table gives the results.

From the above data it is seen that even 120 cc. of concentrated sulphuric acid given daily did not produce a change in the acidity of the milk. The hydrogen ion concentration of the milk also remained constant, although the urine became distinctly acid. The urine was distinctly alkaline before the acid was fed, having a pH of 8.21 and only 0.27 per cent of the nitrogen in the form of ammonium salts. During the experiment the urine became distinctly acid having a pH of 5.83 on January 19, and 6.35 per cent of the nitrogen in the form of ammonium salts on January 16. This shows that the acid was absorbed into the blood stream and that it required a distinct effort to eliminate it. From these data we can conclude that the ration does not influence the acidity of the milk.

A SUGGESTED MODIFICATION IN THE USE OF THE ACID TEST

We are confronted with these two facts: (1) the high apparent acidity of milk is not undesirable, and (2) even if it were, it could not be reduced by a change in the ration. We should, therefore, use a test in grading milk which will not reject normal fresh milk with a high apparent acidity.

The ideal test for grading milk should be a measure of the extent to which the normal milk has undergone change. The acid test as it is now used is not such a measure, it merely measures acidity without differentiating between apparent acidity and acidity due to fermentation. However, it could be modified to approach the ideal test.

TABLE 2

Data on reaction of milk and urine

DATE	MILK			URINE				
	Titratable acidity	pH	Coagulation	Time voided	pH	Per cent total N	Per cent ammoniacal N	Per cent of total N as NH_3
			minutes					
December 12	0 132	6 76	20—					
December 19	0 132	6.745	20—					
December 20	0 128	6.75	20—					
December 23	0.132	6 75						
December 24	0.139	6 78	20—					
December 26	0.124	6 765	20—					
December 27	0 124	6 76	20—					
December 28	0.128	6.75						
December 29	0.128	6.76	20—	4.30 a.m.	8.21	1 61	0 0044	0 27
Changed from original ration, giving 30 cc. of concentrated sulphuric acid daily								
December 30	0.128	6 77						
December 31	0.128	6.78						
January 2	0 139	6 75	20—					
January 3	0.132	6.78	20—	2.15 p.m.	7.30	1.84	0 0086	0 47
January 4	0 128	6.82						
Increased to 40 cc. of concentrated sulphuric acid								
January 5	0 135	6 77						
January 6	0 132	6 75						
January 7	0.130	6 77		4.30 a.m.	7 98	1 25	0.0036	0.28
January 8	0 132	6 77		2.30 p.m.	7 71	0 64	0 0020	0.31
Increased to 80 cc. of concentrated sulphuric acid								
January 9	0.132	6.75						
January 10	0.132	6 76		2.00 p.m.	6 897	1.03	0.004	0.39
January 10	0 132	6 74						
January 11	0.132	6 76						
January 12	0.135	6 73		2.15 p.m.	6 072	0 946	0 0244	2.5
January 13	0.132	6 725	20—					
January 14	0 135	6 72						
Increased to 120 cc. concentrated sulphuric acid								
January 15	0.135	6 70						
January 16	0.132	6 70	20—	4.00 p.m.	6.102	0.672	0.0424	6.35
January 17	0 132	6.70						
January 19	0.128	6.76		4.30 a.m.	5 83	1 331	0.0468	3.50
January 20	0.128	6.73	20—	4.30 p.m.	5.94	0.93	0.0296	3.18
January 21	0 128	6.78						
Changed back to original ration								
January 22	0.135	6.73						
January 24	0 128	6.76	20—					
January 26	0 117	6 78						

The following procedure is suggested, especially in cases where the acidity is persistently high and very evidently due to a high apparent acidity.

1. Determine the apparent acidity of the milk at intervals of several weeks. The acidity runs quite constant.

2. Allow an increase in acidity (e.g., 0.03 per cent) due to slight fermentation that is likely to occur before delivery.

3. If the apparent acidity at the farm was 0.17 per cent then reject the milk if the acidity exceeds 0.20 (0.17 + 0.03).

SUMMARY AND CONCLUSIONS

1. Milk with a high apparent acidity is not undesirable.

2. The acidity of the milk is not influenced by the ration.

3. In cases where the high acidity of the milk delivered is due to a high apparent acidity and not to fermentation, the acid test should be so modified that it will accept such milk.

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(3) From direct and indirect reports to us.
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THE VALUE OF THE PUREBRED SIRE IN INCREASING THE PRODUCTION OF A SCRUB HERD[1]

ANDREW C. McCANDLISH

Dairy Husbandry Section, Agricultural Experiment Station, Ames, Iowa

Preliminary reports from the Iowa Station have shown the profound influence of environment and breeding in increasing the production of a scrub herd and the results which have become available since the publication of these reports further emphasize the purebred dairy sire as a valuable factor in increasing the producing ability of a herd.

PLAN OF INVESTIGATION

In the summer of 1907 a number of scrub cows were purchased in Arkansas and moved to the Iowa Station. These animals were very inferior individuals and had received very poor feed and care. They were of no known breeding, were very unprepossessing in appearance and gave no indications of being valuable dairy animals. The influence of good feed and care on the production of these animals was studied, as has already been reported and at the same time they were used in the breeding investigation.

The scrub cows were mated to purebred dairy bulls of the Holstein, Guernsey and Jersey breeds. The heifers resulting from such matings were saved and mated to bulls of the same breed as their sires. Milk and butterfat records have now been obtained on two generations of grades and some of the third generation, or those carrying 87½ per cent of the blood of

[1] This is supplementary to work already published, viz.:

Influence of Environment and Breeding in Increasing Dairy Production. 1916. H. H. Kildee and A. C. McCandlish, Ia. Ag. Exp. Sta. Bul. 165.

Influence of Environment and Breeding in Increasing Dairy Production. II. A. C. McCandlish, L. S. Gillette and H. H. Kildee, Ia. Ag. Exp. Sta. Bul. 188, 1919.

the recognized dairy breeds, are now in the herd, though their production records are not as yet available.

The records used in comparing the scrub, half-blood, and three-quarter-blood cows are all on the mature basis. If a heifer has only one record, it is calculated to the mature basis; where more records are available, then they are placed on the mature basis and the average of the records secured. For computing the record on the mature basis, the following percentages secured at this station from a study of the records of 10,000 cows were used.

TABLE 1

Percentage of mature production expected of immature heifers

AGE	PER CENT
Yearlings	70
Two-year-olds	80
Three-year-olds	85
Four-year-olds	95

The factors studied in this investigation are of a very varied character but only those relating to the use of purebred dairy sires need be mentioned here.

DISCUSSION OF RESULTS

A number of grade animals sired by purebred bulls and descended from the scrub cows have now completed records. These will be studied in two groups—the first generation grades, or those carrying 50 per cent of the blood of one of the recognized dairy breeds, and the second generation grades, or those carrying 75 per cent of the blood of one of those breeds. The only way to determine correctly the value of a bull is to compare the records of his daughters with those of their dams, though there are difficulties connected even with this method as will be shown later. This method can not be used for the purposes of comparing breeds as all bulls were not mated with the same cows and so were not given equal opportunities to demonstrate their abilities as sires of producers.

FIRST GENERATION GRADES

All the first generation of grades sired by a purebred Holstein bull showed an increase over their dams in milk and butterfat production. The increase varied from 38 per cent in fat and 79 per cent in milk to 68 per cent in fat and 121 per cent in milk, while on the average it was an increase of 89 per cent in milk and 58 per cent in fat.

TABLE 2

First generation grades compared with their scrub dams

DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
Cow number	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
				Holsteins					
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
8	3	2339.5	124.35	68	3	5180.0	209.61	121	68
52	7	3742.3	169.16	69	5	6700.5	282.11	79	67
56	3	3874.6	192.62	77	6	6955.5	266.25	79	38
60	6	3313.2	178.47	207	4	6306.2	287.76	90	61
				Guernseys					
6	8	3715.3	164.93	110	3	3821.1	163.05	3	−1
31	7	3463.3	168.00	288	2	5400.8	308.99	56	84
33	3	4338.5	183.49	87	4	4213.1	179.72	−3	−2
52	7	3742.3	169.16	308	2	5355.9	280.78	43	66
53	7	5258.9	233.63	180	3	3639.0	180.53	−31	−23
[illegible]				253	3	6128.4	298.33	17	28
58	3	3034.5	152.54	175	3	6286.1	322.71	107	112
				Jerseys					
31	7	3463 3	168.00	174	3	5009.0	263.72	45	57
53	7	5258.9	233.63	213	4	4274.5	225.74	−19	−3
60	6	3313.2	178.47	241	2	6137.9	349.42	85	96

In the case of the first generation of Guernsey grades, an even wider variation was noticed. It varied from a decrease of 31 per cent in milk and 23 per cent in fat, due to the use of a poor bull, to an increase of 107 per cent in milk and 112 per cent in fat yield. The Guernsey first grade group contained animals that showed the greatest increase and also the greatest decrease

in fat production from their dams. The average increase in yield was 17 per cent in milk and 27 per cent in butterfat.

The first grade Jerseys showed changes in production as compared with their dams that varied from a decrease of 19 per cent in milk and 3 per cent in fat to an increase of 85 per cent in milk and 96 per cent in butterfat. The average increase in their case was 22 per cent in milk and 34 per cent in fat production.

TABLE 3

Averages for first generation grades and their scrub dams

GROUP	DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
	Number of cows	Number of lactations	Milk	Fat	Number of cows	Number of lactations	Milk	Fat	Milk	Fat
			pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
Holstein....	4	19	3406.2	168.74	4	18	6444.4	265 92	89	58
Guernsey...	6	35	4186.0	189.39	7	20	4899.8	240.96	17	27
Jersey......	3	20	4046 7	194.11	3	9	4933.4	265 88	22	34
Average...	9	47	3968 6	185.66	14	47	5497.8	255.32	39	37

All of the first generation grades when taken as a group showed an increase of 39 per cent in milk and 37 per cent in fat production as compared with their dams.

SECOND GENERATION GRADES

The grades of the second generation ranked high in production, yielding on the average 375.81 pounds of fat per year as compared with a production of 261.93 pounds by their first grade dams and 182.40 pounds by their scrub grand-dams. In every case the production of the second generation grades was at least 50 per cent greater than that of their scrub grand-dams.

The average increase in production for the second generation Holstein grades as compared to their scrub grand-dams was 174 per cent in milk and 130 per cent in fat; the increase was 72 per cent in milk and 94 per cent in fat in the case of the Guernsey grades; and for the Jersey second grades it was 59 per cent in milk and 64 per cent in fat production.

TABLE 4

Two generations of grades compared with their scrub ancestors

DAMS				DAUGHTERS				GRAND-DAUGHTERS				INCREASE IN PRODUCTION			
												First generation		Second generation	
Cow number	Number of lactations	Milk	Fat	Cow nnmber	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat	Milk	Fat
Holsteins															
		pounds	*pounds*			*pounds*	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*	*per cent*	*per cent*
52	7	3742.3	169.16	69	5	6700.5	282.11	281	2	9409.2	347.41	79	67	151	105
								323	1	8847.3	352.69			136	108
56	3	3874.6	192.62	77	6	6955.5	266.25	233	3	13366.2	497.90	79	38	245	158
								282	1	10629.4	402.03			174	109
60	6	3313.2	178.47	207	4	6306.2	287.76	311	2	11069.4	472.31	90	61	234	165
Guernseys															
33	3	4338.5	183.49	87	4	4213.1	179.72	236	2	6345.7	320.16	−3	−2	46	74
								296	2	10283.0	491.74			137	168
53	7	5258.9	233.63	180	3	3639.0	180.53	301	1	8270.1	427.41	−31	−23	57	83
58	3	3034.5	152.54	175	3	6286.1	322.71	298	2	5955.0	309.40	107	112	96	103
								343	1	8521.8	435.85			181	185
Jerseys															
31	7	3463.3	168.00	174	3	5009.0	263.72	245	1	5411.4	287.14	45	57	56	71
60	6	3313.2	178.47	241	2	6137.9	349.42	348	1	5366.9	278.70	85	96	62	56

TABLE 5

Averages for two generations of grades and their scrub ancestors

GROUP	DAMS				DAUGHTERS				GRAND-DAUGHTERS				INCREASE IN PRODUCTION			
													First generation		Second generation	
	Number of cows	Number of lactations	Milk	Fat	Number of cows	Number of lactations	Milk	Fat	Number of cows	Number of lactations	Milk	Fat	Milk	Fat	Milk	Fat
			pounds	*pounds*			*pounds*	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*	*per cent*	*per cent*
Holstein........	3	16	3673.8	167.36	3	15	6757.5	275.66	5	9	10063.2	385.46	84	65	174	130
Guernsey.......	3	13	4496.6	199.62	3	10	4843.8	229.74	5	8	7744.9	388.23	8	15	72	94
Jersey..........	2	13	3394.0	172.52	2	5	5460.5	298.00	2	2	5389.2	282.92	61	73	59	64
Average......	7	36	3847.0	182.40	8	30	5944.7	261.93	12	19	8311.4	375.81	55	44	116	106

The average increase in production for the second generation of grades, when all breeds are combined, was 116 per cent in milk and 106 per cent in fat production—a real tribute to the value of the purebred dairy sire.

POTENCY OF SIRES USED

The importance of the purebred dairy sires has been demonstrated by the work under consideration but another fact of value has also been brought out.

A comparison of the two Guernsey bulls that sired the first generation of Guernsey grades shows that there is a great difference in the value of bulls so far as their ability to sire good producing heifers is concerned.

TABLE 6

Daughters of "Fullwood Hopeful" compared with their scrub dams

DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
Cow number	Number of lactations	Milk*	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
6	8	3715.3	164.93	110	3	3821.1	163.05	3	−1
33	3	4338.5	183.49	87	4	4213.1	179.72	−3	−2

The purebred Guernsey bull "Fullwood Hopeful" had two daughters which averaged only 4045.1 pounds of milk and 172.58 pounds of butterfat while their dams produced nearly as much or 3885.2 pounds of milk and 169.99 pounds of fat.

TABLE 7

Daughters of Imp. Rouge II's Son compared with their scrub dams

DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
Cow number	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
31	7	3463.3	168.00	288	2	5400.8	308.99	56	84
52	7	3742.3	169.16	308	2	5355.9	280.78	43	66
53	7	5258.9	233.63	180	3	3639.0	180.53	−31	−23
				253	3	6128.4	298.33	17	28
58	3	3034.5	152.54	175	3	6286.1	322.71	107	112

On the other hand, Imp. Rouge II's Son demonstrated his ability to sire good producing cows, his five daughters averaging 5360.1 pounds of milk and 275.71 pounds of fat while their dams produced only 4295.6 pounds of milk and 194.05 pounds of fat.

TABLE 8

A comparison of two Guernsey bulls—Imp. Rouge II's Son and "Fullwood Hopeful"

Bull	Dams				Daughters				Increase in production	
	Number of cows	Number of lactations	Milk	Fat	Number of cows	Number of lactations	Milk	Fat	Milk	Fat
			pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
"Fullwood Hopeful" . .	2	11	3885 2	169.99	2	7	4045 1	172.58	4	2
Imp. Rouge II's Son	4	24	4295 6	194 05	5	13	5360 1	275.71	25	43

The bull "Fullwood Hopeful" sired daughters which produced only 2 per cent more butterfat than did their scrub dams and consequently can be looked on as having done nothing to improve the production of the herd. On the other hand Imp. Rouge II's Son was of considerable value as his daughters produced 43 per cent more butterfat than did their scrub dams. This instance shows that even a purebred dairy sire should be carefully chosen if the results are to be entirely satisfactory.

TABLE 9

Three-quarter-blood daughters of Imp. Rouge II's Son compared with their dams

Dams				Daughters				Increase in production	
Cow number	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
87	4	4213.1	179.72	236	2	6345.7	320.16	51	78
				296	2	10283.0	491.74	144	174

In studying the second generation of Guernsey grades interesting information is also evident regarding the value of the bulls used. The bulls Imp. Rouge II's Son, and Rouge II's

Holden were half brothers, both being out of the cow Imp. Rouge II of the Brickfield, and Rouge of Ames was a son of Imp. Rouge II's Son. The close relationship of these bulls renders this study interesting.

TABLE 10

Three-quarter-blood daughters of Rouge II's Holden compared with their dams

DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
Cow number	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
175	3	6286.1	322.71	343	1	8521.8	435.85	36	35

Imp. Rouge II's Son had two daughters out of a daughter of "Fullwood Hopeful" and they were both much better producers than their dam. Their average production was 405.95 pounds of butterfat or 126 per cent more than their dams. Rouge II's Holden had one daughter, out of a daughter of Imp. Rouge II's Son, and her average production was 435.85 pounds of butterfat or 35 per cent more than her dam. There is too little evidence here on which to rank the bulls absolutely according to their ability to sire producers, especially as they were mated to animals of different breeding and producing ability but it is interesting to note that their daughters had about the same average production.

TABLE 11

Three-quarter-blood daughters of Rouge of Ames compared with their dams

DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
Cow number	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
175	3	6286 1	322.71	298	2	5955.0	309.40	−5	−4
180	3	3639.0	180.53	301	1	8270.1	427.41	127	137

Rouge of Ames was mated to two half-blood daughters of Imp-Rouge II's Son and the heifers resulting were both of good producing ability, one giving an average of 309.40 pounds of fat or

4 per cent less than her dam and the other 427.41 pounds of fat or 137 per cent more than her dam. Though there are these discrepancies in the increase obtained through the use of this bull it is evident that he was of considerable value as his daughters produced on the average 348.74 pounds of fat or 39 per cent more than their dams.

TABLE 12

Three Guernsey bulls compared on basis of three-quarter-blood daughters

BULL	DAMS				DAUGHTERS				INCREASE IN PRODUCTION	
	Number of cows	Number of lactations	Milk	Fat	Number of cows	Number of lactations	Milk	Fat	Milk	Fat
			pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
Imp. Rouge II's Son	1	4	4213.1	179.72	2	4	8314.3	405.95	97	126
Rouge II's Holden	1	3	6286.1	322.71	1	1	8521.8	435.85	36	35
Rouge of Ames	2	6	4963.8	251.62	2	3	6726.7	348.71	36	39

It is apparent from the results obtained through the use of these three bulls of similar breeding on the first generation of Guernsey grades that they were all of considerable value in increasing the production of the herd. These daughters had records which were quite comparable and although they did not all bring about the same percentage increase in production it must be remembered that they were mated to cows of very dissimilar producing powers.

INDIVIDUALITY AS A FACTOR IN PRODUCTION

It is a recognized fact that animals of the same breeding may vary widely in producing ability and several good illustrations of this are to be found in the records presented.

If the half-blood Guernsey daughters of Imp. Rouge II's Son out of the scrub cow 53 be studied it will be found that cow 180 produced on the average 31 per cent less milk and 23 per cent less fat than did her dam while cow 253 produced 17 per cent more milk and 28 per cent more fat than did her dam.

Comparable results are to be found in the case of the cows 236 and 296 which are three-quarter-blood Guernseys by Imp. Rouge II's Son and out of the half-blood Guernsey no. 87. These heifers were both better producers than their dam but the increase in butterfat production was 74 per cent in the case of cow 236 and 168 per cent in the case of cow 296.

The two cows 281 and 323 were also full sisters being by the Holstein bull Spring Farm King Pontiac 8th and out of the half-blood Holstein cow 69. They were very similar in producing ability showing almost equal increases in production of butterfat when compared with their dam.

TABLE 13

Studies in individuality

Dams				Daughters				Increase in production	
Cow number	Number of lactations	Milk	Fat	Cow number	Number of lactations	Milk	Fat	Milk	Fat
Half-blood daughters of Guernsey bull—Imp. Rouge II's Son									
		pounds	*pounds*			*pounds*	*pounds*	*per cent*	*per cent*
53	7	5258.9	233.69	180	3	3639.0	180.53	−31	−23
				253	3	6128.4	298.33	17	28
Three-quarter-blood daughters of Guernsey bull—Imp. Rouge II's Son									
87	4	4213.1	179.72	236	2	6345.7	320.16	46	74
				296	2	10283.0	491.74	137	168
Three-quarter-blood daughters of Holstein bull—Spring Farm King Pontiac 8th									
69	5	6700.5	282.11	281	2	9409.2	317.41	151	105
				323	1	8847.3	352.69	136	108

This indicates that a knowledge of the breeding of an animal is not an absolute criterion on which to base an opinion of its producing ability, as the factor of individuality enters in and though breeding is one of the most important factors in determining the producing ability of a herd yet each animal must be judged on its own merits.

SUMMARY

In the work that has been done at the Iowa Station on the grading up of a scrub herd through breeding it has been found that the use of purebred sires is a sure way of increasing milk and butterfat production. It has also been demonstrated, however, that if the best results are to be obtained, the bulls to be used must be selected carefully, as some purebred bulls are not fit to head a scrub herd. The importance of individual variations of necessity demand attention and, even where there is in use a bull that is known to sire good producing heifers, his daughters must be tested as some of them may not come up to the standard of perfection set for the herd. When all the facts of the case are considered the use of good purebred dairy sires is absolutely vindicated.

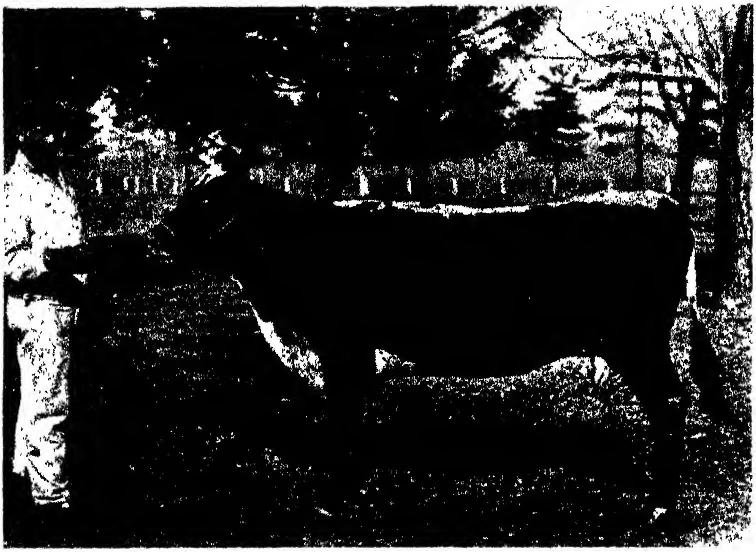

FIG. 1. SCRUB COW NO. 56

Average production 3874.6 pounds of milk and 192.62 pounds of fat

FIG. 2. HALF-BLOOD HOLSTEIN NO. 77, OUT OF SCRUB NO. 56

Average production 6955.5 pounds of milk and 266.25 pounds of fat

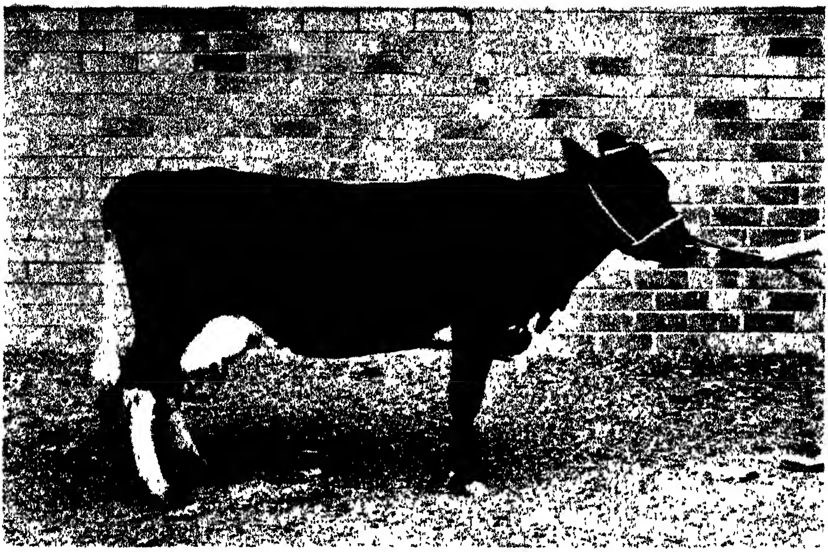

FIG. 3. THREE-QUARTER-BLOOD HOLSTEIN No. 233, OUT OF HALF-BLOOD HOLSTEIN No. 77

Average production 13,366.2 pounds of milk and 497.99 pounds of fat

FIG. 4. SCRUB COW No. 33

Average production 4338.5 pounds of milk and 183.49 pounds of fat

Fig. 5. Half-Blood Guernsey No. 87, Out of Scrub No. 33
Average production 4213.1 pounds of milk and 179.72 pounds of fat

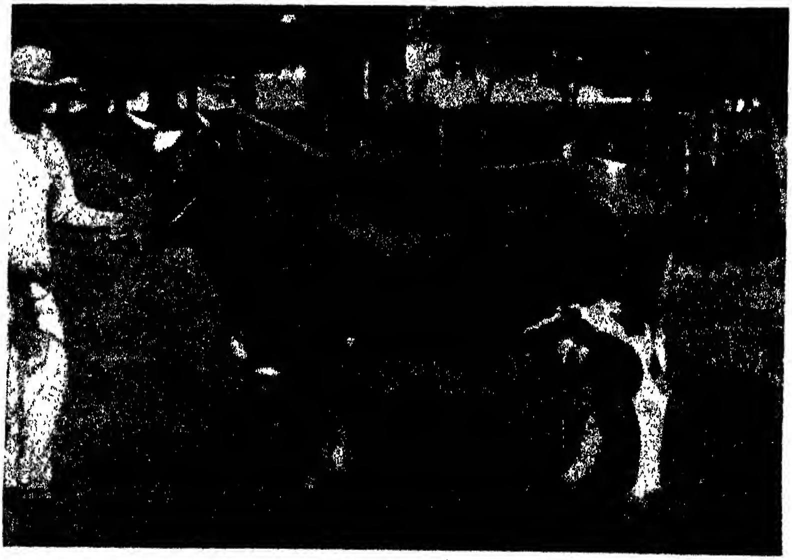

Fig. 6. Three-Quarter-Blood Guernsey No. 236, Out of Half-Blood Guernsey No. 87
Average production 6345.7 pounds of milk and 320.16 pounds of fat

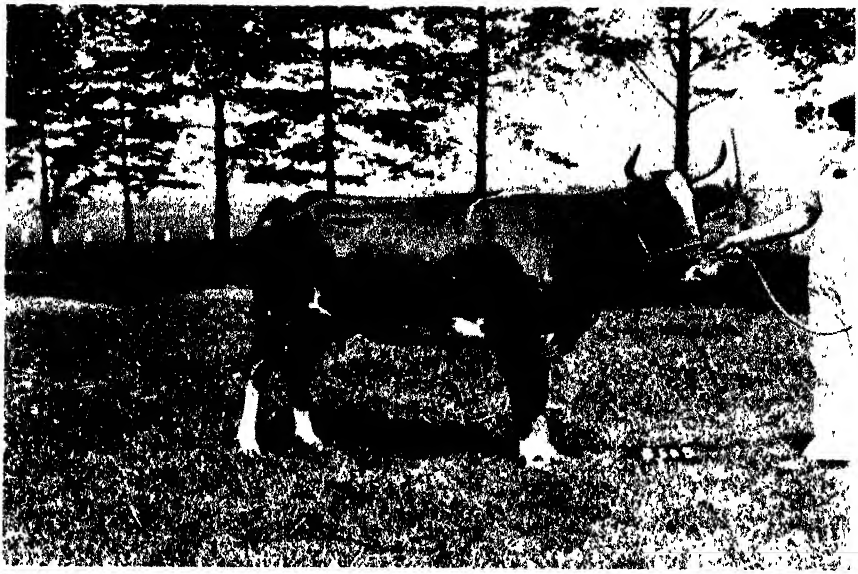

FIG. 7. SCRUB COW NO. 60
Average production 3313.2 pounds of milk and 178.47 pounds of fat

FIG. 8. HALF-BLOOD JERSEY NO. 241, OUT OF SCRUB NO. 60
Average production 6137.9 pounds of milk and 349.42 pounds of fat

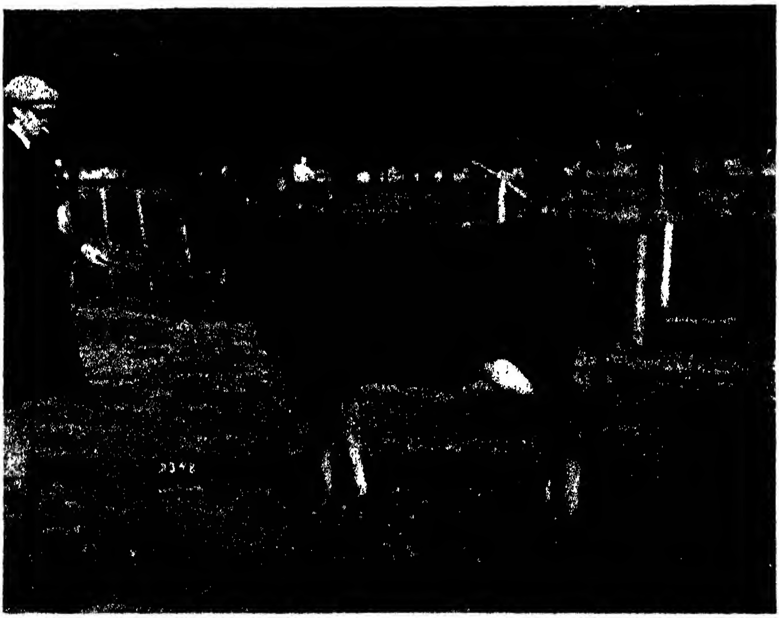

FIG. 9. THREE-QUARTER-BLOOD JERSEY No. 348, OUT OF HALF-BLOOD JERSEY No. 241

Average production 5366.9 pounds of milk and 278.70 pounds of fat

CORN STOVER SILAGE VERSUS CORN SILAGE FOR MILK PRODUCTION[1]

F. B. MORRISON, G. C. HUMPHREY AND R. S. HULCE

Wisconsin Experimental Station, Madison, Wisconsin

The information available on the feeding value of corn stover silage is limited and no experimental data has been reported comparing corn stover silage, made from cured corn stalks, with corn silage, as feeds for milk production.

Rusk, of the Illinois Experiment Station, successfully maintained breeding beef cows through the winter on corn stover silage, and one pound of cotton seed meal daily. Long, of the Missouri Station reports that breeding beef cows gained in weight on a ration of corn stover silage and wheat straw.

In Wisconsin very little of the corn is husked as standing corn. The stalks are needed for feed and are usually harvested with the grain to be made into silage or are fed separate in the dry form. Claims have been made that corn stover silage, that is the stalks with ears removed, is equal in feeding value to ordinary corn silage. It was the purpose of the experiment reported here to obtain information that would corroborate or refute these claims, with reference to milk production.

ANIMALS USED

Eight cows producing an average of about one and one-fourth pounds fat daily at the time the trial was started, were used. They were separated into two equal groups.

PERIODS

Two periods each of four weeks duration with a preliminary week preceding each. The double reversal method of feeding the two kinds of silage was used.

[1] Read at Animal Production Society, Chicago, Ill., December, 1920.

FEEDS USED

Concentrate mixture:

	parts
Ground corn	4
Wheat bran	4
Linseed meal	1
Cottonseed meal	1

Equal amounts of concentrates fed each lot.

Alfalfa hay fed at the rate of slightly less than one pound of hay daily to each 100 pounds of cow weight. Equal amounts of hay fed each lot.

SILAGE

Each kind of silage was fed ad libitum twice daily. The corn stover silage tended to be somewhat dry near the wall of the silo. A good average sample of the silage contained 73 per cent of water. The cows took to the stover silage readily, although they consumed on an average of about 5 pounds less daily per animal than of corn silage.

RESULTS

The average results for the two periods for each ration are shown in the following tables:

TABLE 1

AVERAGE RATION	AVERAGE DAILY YIELD		TOTAL FAT	LOSS IN LIVE WEIGHT
	Milk	Fat		
	pounds	*pounds*	*per cent*	*pounds*
Corn silage ration Corn silage 33.25 pounds Alfalfa hay 8.78 pounds Concentrates 9.39 pounds	27.4	1.05	3.98	156
Corn stover silage ration Stover silage 28.31 pounds Alfalfa hay 8.78 pounds Concentrates 9.39 pounds	24.5	0.98	4.00	110

It will be noted from the above data that the average daily milk production on the corn silage ration was about three pounds more daily per cow than on the corn stover silage ration. A

corresponding relationship existed also in the productions of butter fat. Both lots lost some in live weight. The total loss of weight on the corn silage ration exceeded that on the corn stover ration by 46 pounds. This difference is not great enough to be considered significant.

TABLE 2

Financial summary

Corn silage ration:	
2103.9 pounds grain at $50.00 per ton	$52.60
7448.0 pounds silage at $6.50 per ton	24.20
1964.0 pounds alfalfa at $30.00 per ton	29.46
Total	$106.26
Corn stover silage ration:	
2104.2 pounds grain at $50.00 per ton	$52.60
6352.0 pounds silage at $4.00 per ton	12.60
1964.0 pounds alfalfa at $30.00 per ton	29.56
Total	$94.76

TABLE 3

Feed cost per hundred weight of milk and pound of butter fat

	COST OF MILK PER HUNDRED WEIGHT	COST OF BUTTER FAT PER POUND
Corn silage ration	$1.73	$0.43
Corn stover ration	1.73	0.43

The data shows that the costs per hundred weight of producing milk and per pound of butter fat are the same when the prices applied to corn silage and corn stover silage per ton, bear respectively the relation of $6.50 to $4.00. In other words the price at which the corn stover silage could be figured was 61 per cent of the price at which corn silage was valued. It is planned to carry on a more extensive trial than the one here reported at an early date.

THE ESTIMATION OF BUTTER FAT IN CREAM

HARRY B. SIEGMUND

Analyst, Hendler Creamery Company

AND

R. SEWELL CRAIG

Senior Food Chemist City Health Department, Baltimore, Maryland

It has been stated that one of the greatest difficulties confronting the accurate estimation of butter fat in cream lies in the problem of securing a fair and representative sample. While we readily agree with this observation it has been the product of our investigation to conclude that an even greater source of error arises in an extension of the problem of sampling, namely, in the lack of uniformity which presents itself in many cream samples.

Analysts engaged in the routine sampling and testing of cream are, no doubt, well aware of the churning which occurs in commercial cream during transportation. This phenomenon, which is essentially a coagulation of fat globules, is due primarily to the effect of agitation. Higher stages of acidity favor its development and consequently it is during the warmer months that a greater number of churned shipments are found. However, since it is possible to have a certain measure of the conditions which favor the development of churning during all seasons it is not particularly unusual to encounter it at any time during the year. There are, furthermore, different degrees of churning; it may vary from a condition requiring the closest scrutiny to detect to its more familiar aspect in which large particles of fat can be recognized on the surface of the cream.

The effect of churning upon the accuracy of a test will depend principally upon two factors, the degree of churning and the amount of sample which is used for analysis. The application of this assertion will at once occur to those who have had occasion to sample and test creams which have developed a marked degree

of churning. It is impossible to rely on individual results and it is only by averaging the figures from a large number of tests that the effect of the unevenness is minimized to such a degree that it is practically negligible. The same purpose is served by using a large quantity of sample in such cases. With samples which are churned to a lesser extent the influence is, of course, correspondingly less upon individual results and with entirely homogenous samples the accuracy will depend more upon the precision of the method and skill of the analyst than upon the condition of the sample.

In the testing of cream it is usual to employ one of the extraction processes or the Babcock method. Of the extraction processes, the Roese-Gotleib method is perhaps more widely used than any other method. This method employs from 1 to 2.5 grams of sample. Some tests direct the use of from 3 to 5 grams, but we have found that the use of more than 2.5 grams, particularly of heavy cream, is likely to result in an incomplete extraction of fat by the amount of solvents called for in the several extractions. With the smaller amounts of sample we have had no trouble in completing the extraction in all cases.

A tabulation of our results with this method shows that in ten duplicate fat tests made during the summer months (from August 20 to September 2) the average variation was 1.18 per cent. The greatest single variation was 4.18 per cent and there were a number of duplicate tests which varied more than 2.00 per cent. During the fall (from September 3 to December 16) the average variation of 30 duplicate tests was 0.5 per cent, while a series of 69 duplicate tests made from December 16 to February 23 showed a variation of 0.11 per cent. The greater variation during the summer months was due to the greater degree of partial churning which occurs during this season.

These results indicated rather forcibly the limited application of this method to the field of routine cream testing, a failure which we attribute solely to the difficulty of securing homogenous samples. It is regrettable that there is no convenient apparatus or method by which it would be possible to homogenize samples before analysis. Our experience in testing homogenous samples

of cream has been entirely satisfactory and we have every reason to believe that a preliminary procedure such as we suggest would effectually solve the problem of accurate routine work with this method.

By reason of the larger portion of samples employed in analysis together with its other features of speed and economy, the Babcock method suggests itself at this time as a subject of investigation. We recognized the limitations of its precision when testing high-fat creams but on the other hand when testing partially churned samples its accuracy in representing the fat content of entire consignments as compared with the extraction method appeared to be much greater.

Accordingly, a number of comparative tests were conducted. It was decided to use a 24-bottle steam driven Babcock machine with a speed of about 800 revolutions per minute; a 36-bottle electrically driven machine with a speed of about 1000 revolutions per minute and to compare results with those of the extraction method. By employing only homogenous samples it was possible to use the results obtained by the extraction method as a standard. In the following comparisons we were careful to select only those results in which duplicate determinations by this method checked closely.

The Babcock tests were also made in duplicate, employing an accurately weighed 9-gram sample. After first diluting the 9-gram sample with an equal volume of water the usual procedure for carrying out this test was followed. The fat columns were entirely clear in those cases in which the results were used for comparisons. The Babcock bottles used were of the type which have a bulb in the stem, and are graduated in 0.2 per cent, with a capacity of 25 per cent.

The comparative results are as follows:

NUMBER	EXTRACTION METHOD	ELECTRIC BABCOCK MACHINE	STEAM BABCOCK MACHINE
1	36.60	37.20	38.40
2	40.61	40.70	42.00
3	36.75	39.40	39.20
4	43.84	45.60	45.20
5	36.32	36.40	37.00

It was interesting to note from these figures that although in no case did the three methods check there was nevertheless a characteristic relationship between them. The figures of the extraction method were invariably lower than those by either Babcock process, and the electrically-driven machine gave results which were, as a whole, lower than the steam-driven machine.

In spite of the accredited accuracy of the extraction method and the reliance which we had gained through experience with homogenized samples several additional ether extractions were made in some of the tests. In all cases they failed to show any appreciable difference in the results and thus eliminated the consideration of incomplete extractions. As an additional check it was decided to compare the results of fat tests by this method with the results obtained by determining the total solids, and, after a complete mechanical removal of the fat, the solids-not-fat. The difference between the first and the latter figure gave a fat percentage which approximated the direct fat extraction within an acceptable limit. At least, it served the purpose of showing that the extraction method was more nearly correct than either Babcock process. By reference also to tables showing the computed value for the solids-not-fat content of cream with varying percentages of fat it was possible to further check the relative accuracy of the extraction method.

In seeking to explain the difference in the results obtained by the two Babcock methods a careful study of all factors concerned showed that the sole difference was in the advantage in speed possessed by the electric machine, as before stated, an advantage of about 200 revolutions per minute.

A review of the text books and other publications upon the subject indicated that with machines of our type a minimum speed of about 700 to 800 revolutions per minute was essential to accurate results while directions regarding the maximum speed where rather indefinite, about 1200 revolutions per minute being the highest speed that was noted. In other words, while it was agreed that a certain minimum speed was necessary to bring all of the fat to the top, it was also indicated that a speed much less than this minimum would not accomplish this end

but would result in readings correspondingly low. The higher speeds were not mentioned except as permissible maxima and in no case was any reference made to the influence of such speeds upon the final result.

Nevertheless, upon the assumption that the greater centrifugal force possessed by the electric machine did have some influence upon the fat column, further comparative tests were made at a speed of about 1200 revolutions per minute.

The results of these tests may be tabulated as follows:

NUMBER	EXTRACTION METHOD	ELECTRIC BABCOCK MACHINE
1	38.54	38.80
2	43.49	44.40
3	38.38	39.30
4	34.60	34.80
5	37.73	38.10
6	36.58	37.30

By comparison with the first series of tests it was found that the average variation under the increased speed had dropped from 1 per cent to about 0.60 per cent which quite clearly demonstrated that the additional centrifugal force alone was the responsible agent in effecting the change in variation of results.

In studying the influence of the additional force upon the fat readings it appeared, in the first place, quite obvious that with the least speed employed in these experiments (800 revolutions per minute with the steam-driven machine) the force had been sufficient to accomplish the purpose of bringing all of the fat within the graduated stem of the Babcock bottle. In fact, our findings lead us to the opinion, which we believe has not been previously expressed, that any speed above that minimum necessary to bring all of the fat to the top exerts a correcting influence upon the length of the fat column.

In all of the experiments with the Babcock method we were careful to record only those readings which showed an absolutely clear fat column, consequently we were prepared to reject the possibility of the variation being due to the presence of any solid

particles in the fat. There remained then for consideration the possible occlusion of water or acid, or perhaps both by the fat.

A final series of experiments were conducted with a view of determining this point. We had installed for this purpose a Babcock super-centrifuge, a machine with a guaranteed speed of 1800 revolutions per minute. This machine was operated at a speed of 1600 revolutions per minute, however, during these experiments. The following comparative results were obtained.

NUMBER	EXTRACTION METHOD	ELECTRIC BABCOCK MACHINE
1	33.50	33.60
2	45.18	45.20
3	40.83	40.80
4	39.12	39.20
5	37.49	37.40
6	44.83	44.80
7	40.02	40.00

The difference in the average of the above results is 0.01 per cent, while the greatest single variation is 0.10 per cent.

From the foregoing experiments with the Babcock method as applied to cream testing we believe that we have brought out a new conception of the purpose of centrifugal force. It has been thought, in the testing of both milk and cream, that a centrifugal force sufficient to bring all of the fat within the graduated stem of the Babcock bottle was all that was necessary to produce accurate results. We feel that our experiments have demonstrated the necessity of a force sufficiently powerful to not only accomplish this but in addition to render the fat free of any occluded liquid.

The last series of comparative tests we believe were important in demonstrating that by applying sufficient centrifugal force in the operation of the Babcock method for cream testing it is a relatively easy matter to produce results which compare favorably with those of the ether extraction method.

In concluding, it might be added that we believe that under the conditions now existing the Babcock test is the more suitable method for the purpose of routine cream testing. By employ-

ing a larger portion of sample it is more representative and consequently more accurate with cream samples of varying degrees of uniformity and through its speed and economy it is always possible to heighten the precision of the results by carrying out simultaneously a larger number of tests than can be conveniently done by the ether extraction method as is usually applied to cream testing.

SUMMARY

From the above investigation we would conclude that:

1. The ether extraction method does not give accurate results when applied to samples of cream which are partially churned, consequently it is not suitable for the general routine work of commercial laboratories.
2. The Babcock method has the advantage of minimizing the inaccuracies introduced by the lack of uniformity frequently encountered in cream, by reason of the use of a larger portion of sample in analysis.
3. However, the Babcock method as it is usually employed for cream testing gives high results. We attribute this to the occlusion of water or acid within the fat column.
4. By applying sufficient centrifugal force the fat column can be freed of the foreign liquid. When this has been accomplished the results obtained by this method compare favorably in accuracy and precision to those of the extraction method.
5. Under the present difficulties of obtaining uniform samples we believe that the Babcock method when properly carried out is to be preferred to the ether extraction process as a routine procedure.

THE ACCURACY OF BACTERIAL COUNTS FROM MILK SAMPLES[1]

R. S. BREED AND W. A. STOCKING, JR.

INTRODUCTION

At the present time all of the market milk sold in New York state is graded on a system based upon the number of bacteria present in the milk. Likewise an increasing amount of milk is being bought from dairy farmers on the same basis. This makes it important to all concerned that the methods of analyses used in the grading should be sufficiently accurate to justify the use made of them.

Because of questions that have been raised in regard to the matter, a series of coöperative analyses of milk samples have been made, the results of which are discussed in the present article.

PREVIOUS STUDIES

Because of the importance of the matter, numerous series of comparative analyses have previously been made in many of the public and private bacteriological laboratories in New York State; but the primary purpose of the majority of these tests has been merely to determine whether different analysts, working in the same or in different laboratories, could secure duplicate agar counts which were in close agreement.

The results secured have been such as to cause the majority of bacteriologists to feel that reasonable agreement could be

[1] Condensed from Technical Bulletin 75 issued by the New York Agricultural Experiment Station, Geneva, N. Y., and by the New York State College of Agriculture, Ithaca, N. Y. The analyses on which the report is based were made by R. S. Breed, J. D. Brew, H. J. Conn, W. D. Dotterrer and G. L. A. Rueble from Geneva; and A. M. Besemer, H. M. Pickerell, T. J. McInerney, and G. C. Supplee from Ithaca. Detailed analytical data will be found in the original bulletin, copies of which may be obtained on application to either institution.

obtained where the counts were made by a standard, uniform technique by trained analysts. Yet it has become increasingly evident that carelessness or slight modifications of essential procedures may produce widely divergent counts. The most extensive of the recent series of analyses is that made under the supervision of the late Prof. H. W. Conn (1). Other recent series are those discussed by Hatfield (2) and by Kilbourne (3).

It should not be forgotten, however, that the securing of closely comparable counts of bacteria from duplicate samples by different analysts where but a single method of analysis is used *does not prove that the counts obtained are an accurate or even a reasonably accurate count of the actual number of bacteria present.* It is easily possible that such counts are affected by a constant source of error which affects all duplicate counts proportionately. Or it may even be possible that variable errors completely destroy the accuracy of the counts even when there is no indication of their presence in the final counts.

For example, in the case of agar plate counts from milk, constant errors in count would be produced if all bacteria in milk existed in clumps of a constant average size. Such a condition would not be indicated in the counts as all would be reduced proportionately. Thus if the average clump contained two individuals, all counts would be reduced to one-half of the number of bacteria actually present. It may justly be argued that such an error would have no practical significance because its presence would be already discounted in the standards established for each grade of milk.

The great uncertainty in the present situation does not arise because it is thought that errors of this type exist; but because microscopic examination has shown that the average size of the clumps of bacteria in milk is not constant. In such a situation, the results are, undoubtedly, liable to inconstant errors of such a type that they pass undetected in comparative series of analyses made by the agar plate method. Thus, while all of the counts made from one lot of milk may be reduced to one half their true size by the presence of clumps containing an average of two individuals, another set of duplicate counts may be reduced to

one-third of their true size, another to one-sixth, another to one twenty-fifth, etc.

It is this condition of affairs that has made the development of a second, fundamentally different, method of counting bacteria in milk doubly important. Microscopic methods of counting have now been so perfected that it is possible not only to secure data regarding the actual size of the clumps of bacteria in milk, but also to make comparative analyses of a series of milk samples both by the usual agar plate method and by direct microscopic examination. This permits us to study the accuracy of the counts in a manner not heretofore possible.

Already extended series of comparative analyses have been made and published (4), (5). The analyses mentioned have, however, been largely the work of a single analyst, and are subject to the "constant" and "personal" errors which are always possible where analyses are made by a single person. Some preliminary comparative counts by several analysts from different laboratories were made in the series of counts discussed by Conn; but these were preliminary in nature, and, because of the difficulties involved in continuing the work where the laboratories were so widely separated, the work was discontinued.

For these reasons, the authors of the present paper in 1915 drew up a plan of investigation under which a series of samples of milk were to be analyzed in each of two laboratories maintained by New York State. A preliminary account of the results obtained has already been published in this Journal (6).

DESCRIPTION OF THE METHODS OF ANALYSES USED

In considering the results secured, it should be kept in mind that the counting of bacteria in milk is an arithmetical problem which would be no more difficult than counting the number of beans in a bag, the number of trees in a wood, or the number of seeds in a bushel of mustard seed, if the bacteria could be seen and handled as readily as these objects. However, bacteria are such tiny things that they can be seen only with high magnification, and they may occur in such incredible numbers that

comparisons with beans, trees or even mustard seeds give an inadequate idea of the difficulties involved.

Every one realizes the physical impossibility, or better, the impracticability of counting the trees on 100,000 acres of woodland. It is not only impracticable but physically impossible actually to count the bacteria in a quart of milk or even in a cubic centimeter of milk. In counting bacteria, as in counting trees, recourse must be had to the making of *estimates* of numbers not actual *counts*. So-called bacterial "counts" are not counts in the strict sense of the word, and like other estimates, their accuracy is largely dependent upon the care with which they are made. In order that the attention of the reader may be called to the fact, the word "count" has been placed in quotation marks throughout the body of the paper wherever it is used in the sense of an estimate.

Microscopic methods of counting bacteria. The simplest method of counting objects is by direct observation. In the case of bacteria this is obviously impossible because they are too small to be seen with the unaided eye. However, from the time when Leeuwenhoek (1683) first saw bacteria under his simple microscopes, microscopists have made more or less accurate estimates of the number of bacteria in various substances by direct observation under the microscope.

It is impossible to state who first made estimates of numbers of bacteria in milk by microscopic examination, but it is certain that no extensive use has been made of such methods until recently. (See Breed and Brew (7) for a detailed discussion of the historical development of these methods.)

Certain things prevent making the microscopic counts with absolute accuracy. These may be briefly summed up as follows:

a. There are certain optical limitations which make it difficult to prepare definite measured quantities of milk in such a way as to make all of the bacteria show with sufficient distinctness to permit counting under a microscope.

b. It is impossible to measure with absolute accuracy the exceedingly minute quantities of milk (1/500,000 to 1/300,000 cc.) which are the largest amounts that can be examined satisfactorily at any one time.

c. It is impossible to tell with certainty whether the bacteria seen under the microscope were actually living when the preparation was made.

d. Care must also be taken to prevent the growth and consequent increase in number of bacteria during the time consumed in preparing the material for microscopic examination, and to prevent the introduction of bacteria from extraneous sources.

Some of these difficulties can be partially, or even almost completely, overcome, but as a whole they can never be entirely eliminated by the most skillful analyst.

Agar plate methods of counting bacteria. The second method of counting bacteria under observation is fundamentally different from the first in that it involves inoculating a transparent nutrient jelly with measured quantities of milk containing bacteria. The nutrient jelly containing the bacteria is then incubated until the original bacteria have grown into masses of bacteria which are counted with a low power magnifying lens. These masses are usually termed "colonies" and it is these which are actually counted.

Such a method of counting may be compared to a method of counting seeds in which a measured quantity of seeds are germinated on a carefully prepared area of ground and the counts made from the plants which develop.

Historically, this method of counting bacteria is a direct outgrowth of the use of gelatin as a means of isolating pure cultures of bacteria first introduced by Koch in 1881. In the milk work which has been so extensively developed in the United States, agar has supplanted gelatin as a culture medium, and the method of making counts has been standardized largely through the efforts of members of the laboratory section of the American Public Health Association (8).

A modification of this technique, called the "little plate" method, has recently been developed and advocated for use by Frost (9). This differs from the technique ordinarily used in control laboratories in that the colonies which develop in agar are examined and counted under a compound microscope before they are visible to the unaided eye. Thus the time ordinarily

consumed in waiting for the development of colonies is greatly shortened. In general, this technique has the same advantages as that possessed by the usual agar plate method, and is subject to the same general type of limitations.

These limitations upon the culture methods of counting bacteria are, as in the case of the limitations upon the microscopic technique, such that it is impossible to secure absolutely accurate counts. The chief difficulties may be summed up as follows and may be better understood if the comparison with the planting of seeds on prepared soil is kept in mind.

a. Only those bacteria grow which survive the necessary manipulations and are capable of growth into visible colonies under the conditions of aeration, food, moisture, temperature, etc., which are present. It is never certain that all of the bacteria originally living in the milk have grown and formed countable colonies on the plates.

b. Overcrowding of the colonies on the agar may prevent the development of some bacteria, or single bacterial colonies may grow so rapidly that all other colonies are repressed. The latter, so called "spreaders," are readily recognizable and their presence may be discounted. Likewise repression of colonies through overcrowding is frequently recognizable.

c. A third difficulty is still more fundamental. It arises because the bacteria frequently exist in milk in clumps of twos, threes, fours, or even larger masses. Since these clumps cannot be perfectly separated into their component individuals by any known method of shaking or manipulation, the culture medium is always seeded with many groups of bacteria. As these grow they form a single mass or colony, indistinguishable from colonies which have arisen from single individuals. Counts of colonies are therefore never comparable to counts of bacteria, except in those cases where the bacteria exist in the original milk as isolated individuals.

d. The introduction of extraneous bacteria and increase in number of bacteria after the samples are collected and before the culture medium is inoculated is always possible, even where carefully controlled. As additional colonies thus introduced

cannot be detected from an examination of the plates, this always remains as a possible source of error.

e. Since it is impossible to get the best results where more than 300 colonies are grown on each plate, it becomes necessary to use minute quantities of milk (1/100,000 to 1/1,000,000 cc.) when accurate results are desired from samples giving "counts" in excess of 3,000,000 per cubic centimeter. While this measurement is made by the dilution method (admittedly a very accurate method of measurement), yet inaccuracies of measurement are known to occur.

Skill and care may reduce many of these possible sources of error to a minimum, but, as a whole they cannot be entirely eliminated.

Comparison between microscopic and agar plate methods of counting. Since it is impossible to make counts of bacteria that are known to be absolutely accurate, it becomes very difficult to determine whether more accurate counts can be made by direct observation than by cultural methods or whether the opposite condition holds true. This being the case, it is evident that the common assumption that the agar plate method gives the more accurate results has no real basis upon which to rest.

One point of difference between the two methods should always be kept in mind in considering the accuracy of results. Because of the fact that estimates made from plate counts must be based on a count of colonies, which should not exceed 300 per plate, the amount of milk examined is largest where the bacteria are few in number and continually grows smaller as the number of bacteria increases. It is as if all scattered trees on 10,000 acres of cleared land could be counted, whereas in making estimates of a similar area of woodland only one-tenth of an acre could be examined. Consequently it is probable that both the absolute accuracy and the percentage accuracy of plate counts are at their best in milk containing few bacteria, and that both the absolute and percentage accuracy of results decreases as the number of bacteria increases.

In contrast to this, microscopic counts are made from a small but fairly constant amount of milk regardless of the number of

bacteria present. It is as if one acre plats from 100 different places selected at random could be examined in counting the trees upon 10,000 acre plats regardless of the number of trees present. Under these conditions, the percentage accuracy is at its best, and probably also the absolute accuracy, under intermediate conditions. Where there are few bacteria present, the percentage accuracy becomes poor though, for practical purposes in grading milk, this is of little consequence because the absolute error is not large.[2] A failure to appreciate these differences in the two methods of counting has caused some unjustified criticism of microscopic counts.

PLAN OF THE PRESENT INVESTIGATION

The first work done was to analyze a series of twenty samples of fresh milk of a miscellaneous character (known in this article as series A). Counts were made from these both by the agar plate method and by direct microscopic examination. Chiefly because of the inexperience of some of the analysts with microscopic counting, and because the miscellaneous character of the flora introduced so many possible sources of error that it was impossible to determine the exact cause of particular variations, the results obtained did not throw as much light on the question of the accuracy of the counts as had been expected.

On the other hand, the results from one of the samples which was known to contain a predominant colon flora were so instructive that it was decided to use samples of this type for further work. A second series of samples (series B) inoculated with the colon organism was therefore analyzed on April 10, 1916, and later still (February 7, 1917), a third series (series C) was examined. As the results obtained from series B and C were instructive and explanatory of the results from series A, the former series (B and C) are discussed first.

[2] The meaning of absolute and percentage accuracy as here used can be made clearer by a simple example. The percentage difference between 1000 and 2000 is the same as the percentage difference between 1,000,000 and 2,000,000; but the absolute difference in the first case (1000) is much smaller than the absolute difference in the second case (1,000,000).

SERIES B. SAMPLES INOCULATED WITH AN ORGANISM OF THE COLON GROUP

The advantage of the colon organism for the purpose in hand rises from the fact that it tends to live in milk as isolated individuals, only occasionally forming clumps of two, four or rarely more individuals. Likewise, it is always found evenly distributed throughout microscopic preparations of milk whenever it is present. It also grows well on ordinary media and at ordinary incubation temperatures. Thus "counts" carefully made from milk containing this organism may be expected to be nearly free from the sources of error previously discussed.

In order to have a series of checks and counter checks upon the accuracy of the results, it was decided to use but three batches of milk, each batch to be analyzed in triplicate by each analyst. The three batches were in each case prepared from a liter of a high grade, freshly-drawn milk known to contain very few bacteria. The first liter was inoculated with 2.5 cc. of an actively growing culture of an organism of the colon group, the second liter with 5 cc., and the third liter with 10 cc. of the same culture. Thus it was expected that the final "counts" would show ratios of approximately 1:2:4. From a rapid microscopic examination of the first liter of milk it was expected that the final "counts" from this milk would be between 100,000 and 500,000 per cubic centimeter, and directions for making dilutions were given accordingly.

Ten samples, each containing about 15 cc. of milk, were sent to each of six analysts. No. 1 was a sample of the high grade fresh milk used as a base in preparing the inoculated milk. Nos. 2, 3 and 4 were samples from the liter of milk containing the smallest amount of the colon culture. Nos. 5, 6 and 7 were from the second liter of inoculated milk, while nos. 8, 9 and 10 were from the liter of milk containing the largest number of colon organisms. This distribution of samples resulted in eighteen separate analyses of each of the three liters of inoculated milk by two different methods, a total of 108 analyses. A further check on the final results was established by having all petri

dishes prepared in triplicate from each of two dilutions. The plates were recounted in each case by a second analyst in order that any carelessness in counting might be eliminated. Likewise, the microscopic preparations were made in duplicate from each sample, and they were also recounted by a second analyst. The six sets of samples were prepared at Geneva at 7.00 a.m., were thoroughly iced, and three sets forwarded by messenger to Ithaca. The analytical work was started in both laboratories about 10.00 a.m., and the petri plates and microscopic slides were prepared in all cases before noon. In one respect the samples used in this series were not perfect as later examination showed that masses of bacteria, which did not break apart readily, had formed in the thin film of cream on the skim milk culture. Consequently, occasional groups of 10, 20 or more individuals were found in the final microscopic preparations.

To facilitate comparisons between the results secured by the two different methods, standard deviations and coefficients of variability have been computed for the estimates of numbers per cubic centimeter as reported for each sample; but no further mathematical analysis of the data has been made.

a. Agar plate counts

Technique used. The analysts were instructed to prepare dilutions as follows: Sample 1—1:10 and 1:100; samples 2, 3 and 4—1:1,000 and 1:10,000; samples 5 to 10—1:10,000 and 1:100,000. These were made by using freshly prepared and accurately measured 9 and 99 cc. water blanks. One cubic centimeter pipettes were used by all analysts, but those used at Ithaca were all of the type with two graduation marks, while those used at Geneva were of the type with a single graduation mark. As the latter were supposed to have been calibrated to *deliver* 1 cc. quantities, analysts B and D merely emptied them carefully in each case as used, and did not rinse them by drawing the dilution water into the pipette.

All analysts were supplied from a single lot of agar (1 per cent Difco peptone, 1 per cent lactose, 0.3 per cent Liebig's beef

extract, 1.5 per cent air dried agar) prepared at the Ithaca laborratory. The acidity of this agar, before adjusting, was 1.6 per cent normal to phenolphthalein, and by the addition of NaOH it was reduced to 1.1 per cent. No record of the H-ion concentration was made.

Incubation temperatures were not definitely controlled in all cases, but they were between 25° and 30°C. Plates were counted at the end of three days when the colonies were well developed. Troublesome spreaders were practically absent, and recounts of the colonies on the plates were in all cases in close accord with the first counts.

The "counts" for samples 2, 3 and 4, as reported here, were secured by averaging the counts from the individual plates from both dilutions; while the counts from the 1:100,000 dilutions were usually discarded for the remaining samples, as they ordinarily showed less than 20 colonies per plate.

Counts obtained. A summary of the results are given in table 1. The individual analysts obtained very regular results as indicated by the standard deviations and coefficients of variability given in table 3. The coefficients of variability ranged from 7.7 for samples 2, 3 and 4 to 13.8 for samples 5, 6 and 7 with an average coefficient of variability of 11.1.

The tabulation of results revealed a tendency of the part of the Geneva men (B, C, and D) to report lower "counts" than those reported from Ithaca, a tendency which had been previously noted in series A. Thus in series B, only nine out of 27 "counts" from the Geneva laboratory were higher than the final averages, while 20 out of 27 "counts" from the Ithaca laboratory were higher than the average figures.

As the differences were relatively small, and as one of the Geneva men (C) who rinsed his pipettes obtained higher counts than the others, a suspicion arose that they were caused by inaccuracies in the measurements of the milk and of the dilution waters. Consequently, the 1 cc. pipettes used were recalibrated, whereupon it was found that the use of the one mark pipettes without rinsing in the dilution waters was causing a small but

TABLE 1

Series B. Summary of plate and microscopic "counts"

Sample number	Analyst*	Plate "count per cubic centimeter"	Analyst*	Group "count per cubic centimeter"		Individual "count per cubic centimeter"	
				Average for each analyst	Combined average	Average for each analyst	Combined average
1		390			3,000		4,000
2–4	BB	325,000	BB	†262,000	282,000	†499,000	494,000
	BD		BD	303,000		489,000	
	CC	375,000	CA	275,000	241,000	430,000	405,000
	CB		CB	206,000		381,000	
	DD	323,000	DD	291,000	259,000	435,000	405,000
	DC		DA	227,000		376,000	
	FF	378,000	FF	301,000	343,000	385,000	562,000
	FI		FI	386,000		739,000	
	HH	330,000	HH	211,000	216,000	276,000	293,000
	HF		HF	221,000		310,000	
	II	347,000	II	293,000	220,000	773,000	731,000
	IH		IH	147,000		690,000	
Final av....		346,000			260,000		482,000
5–7	BB	558,000	BB	†559,000	585,000	†1,018,000	993,000
	BD		BD	611,000		969,000	
	CC	650,000	CA	549,000	490,000	852,000	803,000
	CB		CB	432,000		755,000	
	DD	602,000	DD	640,000	582,000	1,097,000	948,000
	DC		DA	525,000		798,000	
	FF	621,000	FF	545,000	550,000	816,000	787,000
	FI		FI	556,000		758,000	
	HH	658,000	HH	411,000	442,000	617,000	660,000
	HF		HF	473,000		702,000	
	II	754,000	II	609,000	432,000	865,000	689,000
	IH		IH	255,000		513,000	
Final av....		640,000			514,000		813,000
8–10	BB	1,410,000	BB	†1,127,000	1,165,000	†1,919,000	1,946,000
	BD		BD	1,204,000		1,974,000	
	CC	1,170,000	CA	1,083,000	982,000	1,686,000	1,584,000
	CB		CB	882,000		1,483,000	
	DD	1,205,000	DD	1,513,000	1,339,000	2,475,000	2,091,000
	DC		DA	1,166,000		1,708,000	
	FF	1,551,000	FF	822,000	969,000	1,473,000	1,472,000
	FI		FI	1,116,000		1,472,000	
	HH	1,491,000	HH	567,000	791,000	969,000	1,240,000
	HF		HF	1,015,000		1,510,000	
	II	1,470,000	II	895,000	762,000	1,230,000	1,090,000
	IH		IH	629,000		949,000	
Final av....		1,383,000			1,001,000		1,570,000

* The first analyst named made the plates or slides. The second counted them.

† As Analysts A, B, and D examined 1 cu. mm. of milk in making their "counts," the exact number of groups, or of bacteria that they saw is obtained by dividing their results by 1000. The remaining analysts examined a little more than 1 cu. mm.

detectable loss as they were calibrated to *contain* 1 cc. and did not *deliver* the full amount.

In order to test the matter further, the Geneva analysts used the same pipettes for the next series of analyses, carefully rinsing

TABLE 2

Series B. Observed ratios between the counts from the 3 liters of inoculated milk. Theoretical ratio 1 : 2 : 4

ANALYST*	RATIO FOR PLATE "COUNT"	ANALYST*	RATIO FOR GROUP "COUNT"	RATIO FOR INDIVIDUAL "COUNT"
BB	1:1.70:4.30	BB	1:2.13:4.30	1:2.04:3.85
BD	1:1.74:4.39	BD	1:2.02:3.97	1:1.98:4.04
CC	1:1.72:3.12	CA	1:2.00:3.94	1:1.98:3.92
CB	1:1.76:3.13	CB	1:2.10:4.28	1:1.98:3.89
DD	1:1.96:3.93	DD	1:2.20:5.20	1:2.52:5.70
DC	1:1.77:3.54	DA	1:2.31:5.14	1:2.12:4.54
FF	1:1.59:4.06	FF	1:1.81:2.73	1:2.12:3.83
FI	1:1.69:4.15	FI	1:1.44:2.92	1:1.03:1.99
HH	1:2.03:4.31	HH	1:1.95:2.69	1:2.24:3.51
HF	1:1.95:4.71	HF	1:2.14:4.59	1:2.26:4.87
II	1:2.10:4.06	II	1:2.08:3.05	1:1.12:1.59
IH	1:2.25:4.43	IH	1:1.74:4 21	1:0.50:0.92
Average	1:1.85:4.00		1:1.98:3.85	1:1.69:3.28

* The first analyst named made the plates or slides. The second counted them.

TABLE 3

Series B. Summary of table 1

SAMPLE NUMBER	PLATE "COUNT" PER CUBIC CENTIMETER			GROUP "COUNT" PER CUBIC CENTIMETER			INDIVIDUAL "COUNT" PER CUBIC CENTIMETER		
	Final averages	Standard deviation	Coefficient variation	Final averages	Standard deviation	Coefficient variation	Final averages	Standard deviation	Coefficient variation
2–4	346,000	26,600	7.7	260,000	69,700	26.8	482,000	136,000	33.6
5–7	640,000	88,300	13.8	514,000	124,000	24.1	813,000	221,000	27.2
8–10	1,383,000	163,000	11.8	1,001,000	213,000	21.3	1,570,000	377,000	24.0
Average..................			11.1			24.1			28.3

each pipette as used. Likewise, in order to secure more accurate dilutions, 1:10 dilutions were prepared for each sample by withdrawing 5 cc. of milk with a 5 cc. pipette, and adding this to 45 cc. of sterile water. Subsequent dilutions were prepared with 1 cc. pipettes. The results secured with this improved system of measurement are discussed on page 60.

The ratios between the final average "counts" made by each analyst, as shown in table 2, agree well with the expected ratio of 1:2:4. It is worth noting, however, that in all but three of the twelve triplicate ratios, the first ratio is less than the 1:2 ratio which was expected. As the average ratio between the first and last "counts" was almost exactly 1:4, this condition raised the question whether the second liter of milk may not have failed actually to receive the full number of bacteria that were supposed to have been added. The final average ratio for all of the plate "counts" was 1:1.85:4.00.

The regularity of the plate "counts" and the agreement between the observed and the expected ratios make it probable that the figures given by the analysts were actually accurate estimates of the number of bacteria present. Yet it must be remembered, as already explained, that both of these things might be true in the case of agar plate "counts" which were actually very inaccurate.

All of the analysts agreed that Sample No. 1 contained very few bacteria, the agar plate "counts" being less than 800 per cubic centimeter in all cases. The final average "count" was 390 per cubic centimeter. The results show that this milk contained so few bacteria that the number present could not have influenced the final figures as reported for the remaining samples in the series.

b. Microscopic counts

Counts of two kinds were made by microscopic examination of the stained dried milk. The first of these, spoken of in this paper as the "group" count, was obtained by regarding each isolated organism and each actual clump of two or more organisms as single "groups." From theoretical considerations, it

was expected that the estimate based on this count would be lower than the agar plate "counts" as the latter are based on the growth of the "groups" after they are partially broken apart in the preparation of the dilution waters.

A count of individual bacteria was also made, any organism showing clear indication of approaching division being recorded as two individuals. It was expected that the estimate based on this count would in all cases be larger than the agar plate "count."

All analysts examined 100 fields of the oil immersion lens on each of two duplicate preparations from each sample, and nearly all recorded not only the number of bacteria seen, but also the number of twos, threes, fours, etc. Analysts A, B, and D, who were more experienced in the technique than the others, used special ocular micrometers ruled in circles and quadrants of circles, and adjusted the tube length of their microscopes so that the dried solids from 1/600,000 cc. of milk were visible in each microscope area counted. As only the central part of the field was used, the definition was clear and sharp and the danger of overlooking bacteria was lessened. Each of the three analysts mentioned examined 200 fields for each sample of milk, so that each counted the bacteria in 1/3000 cc. regardless of the number present.

The less experienced men used the entire field of the microscope and did not adjust their instruments so that it was necessary for them to use an irregular number in their computations. In all cases they examined a larger amount of milk than did the experienced men, but their counts were, nevertheless, decidedly less regular than those returned by the experienced men.

Table 1, last four columns, gives the average figures obtained for each of the three batches of colon inoculated milk. In this case both the original count and the recounts are given and these are then combined into a final average figure for each of the six samples.

Computations of the standard deviations are given in table 3 with their coefficients of variability. From this table it will be seen that the coefficients of variability of the group "counts"

vary from 21.3 for the group of samples containing the largest number of bacteria to 26.8 for the group of samples containing the fewest bacteria. The average for all samples was 24.1.

The coefficients of variability for the individual "counts" were larger (as was to be expected) and varied from 24.0 for the group of samples having the largest number of bacteria to 33.6 for the group of samples containing the fewest bacteria. The average for all samples was 28.3.

In spite of the variability of the microscopic "counts," the irregularities counterbalanced each other in such a way that the final average ratios, as given in table 2, are very close to the expected ratio of 1:2:4. Thus, for the group "counts" the observed ratio was 1:1.98:3.85, while that for the "counts" of individual bacteria was 1:1.69:3.26. It will be observed that all of these ratios are lower than the expected ratios. As there are several possible explanations for this condition, it is useless to speculate upon them.

Some fairly wide variations from the expected ratio will be found among the ratios actually obtained by the individual analysts which are recorded in table 2. However, many of the ratios obtained agree well with the expected ratio.

It should be pointed out in connection with these "counts" that neither agreement in results nor the fact that the observed and the expected ratios are on close agreement prove that the "counts" as given are truly accurate. These conditions raise a strong probability that the final average figures are very close approximations to the actual number of groups of bacteria present per cubic centimeter, but they do not *prove* the accuracy of the results.

c. Comparison between the plate and the microscopic counts

It is not until the results obtained by the two different methods of counting are compared with each other that the probable accuracy of the counts can be established with reasonable certainty. An examination of the results as given in table 1 shows that the final average group "counts" are invariably lower than

the final average plate "counts," while the final average individual "counts" are higher than either of the other counts. This is as it should be if the results were truly accurate, for it is to be expected that the groups were somewhat broken up in the process of preparing the plates, thereby causing more colonies to appear on the plates than there were groups originally present in the milk. However, it is not to be expected that all groups were broken into their component individuals, so that the plate "count" should never be as large as the individual "count" if both were truly accurate.

Even the average "counts" as reported by each individual analyst for each sample usually showed a plate "count" intermediate between the two microscopic "counts." As is to be expected, however, this relationship is not as perfectly maintained as it is in the case of the final average "counts." Thus in eight cases out of a possible 54, the plate "counts" reported were less than the group "counts" as reported, while, in 17 cases out of a possible 54, the plate "counts" exceeded the individual "counts." Although this analytical work was done with care, it is evident that errors in "counts" were not absolutely eliminated.

The test for accuracy just discussed is a relatively severe one, for it must be remembered that the milk used for analysis contained very small groups of bacteria (average size 1.6 individuals). This means that the individual "count" is only 1.6 times the size of the group "count" if both are perfectly made, so that large variations in the plate "counts" would cause these to be larger or smaller than the microscopic "counts." Since the conditions found indicate that all three counts represent fairly accurately the conditions as they exist, it then becomes possible, by a comparison between the group and the plate "counts" to determine how much the clumps were broken apart by the shaking in the dilution waters. Thus we find that, whereas the average group in the original milk from which samples 2, 3, and 4 were prepared, contained 1.85 individuals, the average group in the dilution water contained but 1.39 individuals. In the case of samples 5, 6, and 7 the average size of the group was

reduced from 1.58 to 1.27 by the shaking and dilution process; while in samples 8, 9, and 10 the average size of the groups was reduced from 1.58 to 1.13 individuals.

One of the most interesting comparisons which can be made between the three types of counts is that of their coefficients of variability. By examining these in table 3, it will be seen that the average coefficient of variability for all of the plate "counts" in series B was 11.1. On the other hand, the similar value for the group "count" is 24.1 and for the individual "count" it is 28.3.

This shows at once that the microscopic "counts" were more variable than were the plate "counts," a fact which is evident even on a casual inspection. There are certain things which should be kept in mind, however, in comparing these coefficients of variability, namely, that such variations may be produced by the limitations in the technique itself, by differences in the skill of the analysts, or by actual differences in the number of bacteria or groups of bacteria present in the quantities of milk examined by the different analysts.

The greater variability of the individual "counts" as contrasted with the group "counts" is, for example, due to the fact that it is always affected by one more source of variation than is the group count, namely differences in the number of individuals found in the groups. As both the group "counts" and the individuals "counts" were made from identical portions of the original samples of milk, the greater variability of the latter "counts" is caused by the fact that some analysts chanced to find larger sized groups than did others.

SERIES C. SAMPLES INOCULATED WITH AN ORGANISM OF THE COLON GROUP

As all of the analysts felt that the accuracy of the work thus far done could be still further improved as a result of the experience gained, it was decided to duplicate the last series of analyses, introducing such improvements in technique as had been suggested by the results secured.

Circumstances, however, prevented its repetition until February 7, 1917, at which time only four of the analysts who had participated in the work of both series A and B were available. The group of six was therefore completed by including one man who had participated in the work of series A only, and one man who had participated in the work of series B only.

Each analyst knew the general nature of the samples furnished, and knew something of the results as they were obtained in the laboratory in which he worked; but no comparisons were made between the "counts" as obtained in the two laboratories until the final reports were ready. These conditions were permitted as the work of every analyst was checked by a second analyst, and every man was keenly interested in finding the true state of affairs regardless of any preconceived ideas.

Six sets of samples were prepared at the Geneva laboratory. Three of the sets were sent to Ithaca by messenger as before, and three retained at Geneva. Sample 1 was taken from a high grade fresh milk which was used as the base for the inoculated samples. In preparing the three liters of inoculated milk for sampling, the procedure followed was to add enough of the colon culture to a liter of milk to give a count in excess of 1,000,000 per cubic centimeter as determined roughly by immediate microscopic examination. Then 500 cc. of this milk was diluted with 500 cc. of the uninoculated fresh milk to make a second liter of milk which presumably contained exactly one-half of the organisms present in the first liter. Then 500 cc. was taken from the second liter, and added to another 500 cc. portion of the uninoculated milk, making a third liter of milk which presumably contained one-half of the organisms from the second liter, or one-fourth of the organisms from the first liter. Samples 2, 3, and 4 were prepared from the third liter of milk; samples 5, 6, and 7 from the second liter; and samples 8, 9, and 10 from the first liter. Thus the final average "counts" from these three groups of samples were expected to show the ratio of 1:2:4 as before.

TABLE 4

Series C. Summary of plate and microscopic "counts"

SAMPLE NUMBER	ANALYST*	PLATE "COUNT PER CUBIC CENTIMETER"	ANALYST*	GROUP "COUNT PER CUBIC CENTIMETER": Average for each analyst	GROUP "COUNT PER CUBIC CENTIMETER": Combined average	INDIVIDUAL "COUNT PER CUBIC CENTIMETER": Average for each analyst	INDIVIDUAL "COUNT PER CUBIC CENTIMETER": Combined average
1		623			5,500		7,250
2–4	BB	885,000	BB	†868,000	593,000	†1,187,000	813,000
	BC		BH	318,000		439,000	
	CC	784,000	AA	721,000	685,000	1,150,000	1,028,000
	CE		AI	650,000		906,000	
	EE	755,000	EE	783,000	674,000	1,297,000	1,075,000
	EB		EF	566,000		853,000	
	FF	842,000	FF	781,000	754,000	1,135,000	1,160,000
	FH		FE	728,000		1,184,000	
	HH	830,000	HH	451,000	680,000	642,000	935,000
	HI		HB	910,000		1,227,000	
	II	827,000	II	752,000	778,000	1,072,000	1,117,000
	IF		IA	804,000		1,163,000	
Final av....		821,000			694,000		1,021,000
5–7	BB	1,605,000	BB	†1,564,000	1,035,000	†2,238,000	1,493,000
	BC		BH	506,000		747,000	
	CC	1,470,000	AA	1,442,000	1,376,000	2,230,000	2,042,000
	CE		AI	1,310,000		1,854,000	
	EE	1,620,000	EE	1,519,000	1,368,000	2,468,000	2,152,000
	EB		EF	1,217,000		1,837,000	
	FF	1,715,000	FF	1,414,000	1,482,000	2,153,000	2,348,000
	FH		FE	1,550,000		2,543,000	
	HH	1,610,000	HH	864,000	1,333,000	1,275,000	1,806,000
	HI		HB	1,802,000		2,336,000	
	II	1,670,000	II	1,458,000	1,539,000	2,079,000	2,240,000
	IF		IA	1,620,000		2,400,000	
Final av....		1,615,000			1,356,000		2,014,000
8–10	BB	3,600,000	BB	†3,443,000	2,672,000	†4,796,000	3,862,000
	BC		BH	1,901,000		2,928,000	
	CC	3,710,000	AA	2,758,000	2,783,000	4,367,000	4,191,000
	CE		AI	2,808,000		4,016,000	
	EE	3,680,000	EE	3,148,000	2,947,000	5,086,000	4,594,000
	EB		EF	2,747,000		4,102,000	
	FF	3,620,000	FF	2,559,000	2,595,000	3,583,000	3,934,000
	FH		FE	2,630,000		4,285,000	
	HH	3,340,000	HH	1,750,000	2,772,000	2,781,000	3,895,000
	HI		HB	3,794,000		5,010,000	
	II	3,890,000	II	3,198,000	3,347,000	4,408,000	4,771,000
	IF		IA	3,496,000		5,134,000	
Final av....		3,640,000			2,853,000		4,208,000

* The first analyst named made the plates or slides, the second counted them.

† As all analysts examined 1 cu. mm. of milk in making these "counts," the exact number of groups, or of bacteria seen is obtained by dividing this figure by 1000.

a. Agar plate counts

Technique used. All of the agar used was prepared in a single batch at Ithaca and it had the same composition as before. The acidity of the medium was approximately 1 per cent normal acid to phenolphthalein, and was found to have a reaction of about pH = 7.6.

As already stated, the Geneva analysts were instructed to rinse all 1-cc. pipettes as they were used, and all analysts prepared their first dilutions by adding 5 cc. of milk to 45 cc. of sterile water. Instructions were given to use 1: 10 and 1: 100 dilutions for sample 1; 1: 1,000 and 1: 10,000 dilutions for samples 2, 3, and 4; and 1: 10,000 and 1: 100,000 dilutions for the remaining samples. Later it became evident that these instructions were satisfactory as plates were secured in each case which developed more than 30, and less than 300 colonies. The plates were recounted by a second analyst from the laboratory in which the plates were prepared.

Counts obtained. The average "counts" are given in table 4. From these it will be seen that the high grade milk was again found to have a very low "count," the final average plate "count" being 623 per cubic centimeter. Thus it was sufficiently free from bacteria to serve satisfactorily as a base for the inoculated samples.

The inoculated milk gave higher "counts" than before, the final average plate "count" from samples 2, 3, and 4 being 821,000 per cubic centimeter as contrasted with 346,000 per cubic centimeter for the similar group of samples from series B. With the single exception of the "count" obtained by analyst B for sample 7, the plate "counts" were in close agreement. In the instance mentioned the number of colonies which developed on the plates was much less than developed on the plates made from the duplicate samples by the same analyst, and likewise fewer than the number which developed on the plates made by the other analysts. As the duplicate plates from this one irregular sample agreed with each other, it was concluded that analyst B had inadvertently used a 99 cc. water

blank in place of a 9 cc. blank in preparing the original dilutions. If no results had been at hand for comparison, the error would have remained undetected.

Only minor and insignificant differences appeared in the recounts of colonies from the agar plates.

The tendency of the Geneva analysts to return a majority of the counts which were below the average was practically eliminated, as they returned but 15 out of a possible 26 counts which were lower than the average. On the other hand, the Ithaca analysts returned 12 out of a possible 27 counts which were lower than the average. This improved condition was probably associated with the rinsing of the one mark pipettes and the greater care taken in securing accurate measurements in making the dilutions.

The final average ratio between the plate "counts" was 1:1.97:4.43 (table 5). This is neither decidedly better nor worse than the similar ratio of 1:1.85:4.00 obtained in series B. The differences between the observed and expected ratios are small in both cases. Even the ratios as computed for the individual analysts are free from gross discrepancies. All agreed in reporting that samples 8, 9, and 10 contained more than four times the number of organisms found in samples 2, 3, and 4, making it probable that this was actually the case. In every instance, the ratio between the "counts" for samples 2, 3, and 4 and for samples 5, 6, and 7 was very close to the expected ratio of 1:2.

The maximum and minimum "counts" have been collected in a separate table (table 7). A comparison with the similar results from series B shows the results from series C to be more regular than those previously obtained. This fact becomes more evident from the computed standard deviations and their corresponding coefficients of variability which are recorded in table 6. From this table, it will be seen that the coefficient of variation for both the first and second groups of samples in series C was only 7.1. The similar value for the third group was 10.6, making an average coefficient of variability of only 8.3. This is even better than the average of 11.1 obtained in series B, and indicates that the improved technique and expe-

rience of the analysts resulted in "counts" which were even more regular and, therefore, presumably more accurate than before.

TABLE 5

Series C. Observed ratios between the counts from the 3 liters of inoculated milk. Theoretical ratio 1:2:4

ANALYST*	RATIO FOR PLATE "COUNTS"	ANALYST*	RATIO FOR GROUP "COUNTS"	RATIO FOR INDIVIDUAL "COUNTS"
BB	1:1.84:4.04	AA	1:2.00:3.79	1:1.94:3.80
BC	1:1.79:4.10	AI	1:2.02:4.32	1:2.04:4.43
CC	1:1.88:4.66	BB	1:1.80:3.96	1:1.89:4.03
CE	1:1.87:4.79	BH	1:1.59:5.98	1:1.70:6.67
EE	1:2.13:4.81	EE	1:1.94:4.02	1:1.90:3.92
EB	1:2.17:4.94	EF	1:2.15:4.85	1:2.15:4.81
FF	1:2.22:4.41	FF	1:1.81:3.28	1:1.90:3.16
FH	1:1.86:4.19	FE	1:2.13:3.61	1.2.15:3.62
HH	1:1.99:4.11	HH	1:1.92:3.88	1:1.99:4.33
HI	1:1.89:3.94	HB	1:1.98:4.17	1:1.90:4.08
II	1:2.02:4.60	II	1:1.94:4.25	1:1.94:4.11
IF	1:2.02:4.82	IA	1:2.01:4 35	1:2.06:4.41
Average...	1:1.97:4.43		1:1.95:4.11	1:1.97:4.12

* The first analyst named made the plates or slides. The second counted them.

TABLE 6

Series C. Summary of table 4

SAMPLE NUMBER	PLATE "COUNT"			GROUP "COUNT"			INDIVIDUAL "COUNT"		
	Final averages	Standard deviation	Coefficient variation	Final averages	Standard deviation	Coefficient variation	Final averages	Standard deviation	Coefficient variation
2–4	821,000	58,200	7.1	694,000	69,000	10.0	1,021,000	127,000	12.5
5–7	1,615,000	115,000	7.1	1,356,000	204,000	15.0	2,014,000	347,000	17.3
8–10	3,640,000	385,000	10.6	2,853,000	286,000	10.1	4,208,000	441,000	10.5
Average..................			8.3			11.7			13.4

TABLE 7

Series C. Maximum and minimum plate and microscopic "counts"

SAMPLE NUMBER	PLATE "COUNTS"		GROUP "COUNTS"		INDIVIDUAL "COUNTS"		TOTAL NUMBER OF "COUNTS"
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
1	450	1,150	Less than 3,000	27,000	Less than 3,000	30,000	12
	493	1,010	Less than 3,000	9,000	Less than 3,000	15,000	
2–4	703,000	937,000	252,000	930,000	354,000	1,326,000	36
	713,000	900,000	327,000	927,000	468,000	1,302,000	
5–7	1,380,000	1,870,000	435,000	2,295,000	663,000	3,033,000	36
	1,420,000	1,840,000	531,000	1,728,000	786,000	2,724,000	
8–10	2,950,000	4,600,000	1,632,000	3,900,000	2,463,000	5,268,000	36
	3,130,000	4,520,000	1,635,000	3,816,000	3,556,000	5,232,000	

b. Microscopic counts

However, the most striking change in the character of the "counts" obtained from series C, as contrasted with series B occurred in the microscopic "counts." As before, both group and individual "counts" were made.

Slides were prepared in duplicate from each sample, and all were recounted by a second analyst. As the slides were exchanged between the laboratories, they were in each case recounted by an analyst from the laboratory different from that in which the slides were made. All analysts standardized their microscopes, and used a special ocular micrometer as already described, so that each examined the central portion of the field only, and each examined 1/600,000 cc. of dried milk per field. A complete record was kept of the size of all groups seen.

The effect of the greater care taken in making the "counts," and in the increased skill gained through the experience of the previous series is seen in table 4, where the average "counts" are summarized. Even a cursory examination will show that these results harmonize much more closely than before, and that variations in count from the same samples as great as 100 per cent are practically absent. This is marked improvement over the results from series B as given in table 1.

Moreover, a study of the detailed records indicates that the less experienced men returned "counts" which bear evidence on their face of a greater accuracy than those returned by the same men from series B. None of the men, for example, found more than an occasional bacterium or pair of bacteria in the high grade fresh milk used in sample 1, whereas, in the previous series, the inexperienced men did not scrutinize the objects which they found in sample 1 closely enough, and evidently recorded and counted objects as bacteria which were not bacteria.

On the other hand, in the samples of inoculated milk where the bacteria were numerous, the less experienced men still showed a tendency to report fewer bacteria than did the experienced men who examined the identical slides. This effect is particularly noticeable in the "counts" made by the analyst (H) who had had the least experience in microscopic counting. This effect is chargeable to inexperience and not to carelessness as is shown by the fact that the plate "counts" returned by the men who made the irregular microscopic "counts" are as regular, and presumably as accurate, as any that were made.

An examination of the ratios, as given in table 5 shows that all of the analysts (with the single exception of analyst H) obtained ratios which agree well with the excepted ratio of 1:2:4. A marked improvement was shown in these over the similar ratios from series B. The final average ratios obtained were 1:1.95:4.11 for the group "counts" and 1:1.97:4.12 for the individual "counts." These are almost identical with the expected ratios, and are even more nearly perfect than the similar ratios from the plate "counts."

In order that the variations in "counts" may be studied more readily, the maximum and minimum "counts" returned by all of the analysts are given in table 7.

The greater regularity of these microscopic "counts" as contrasted with those of series B is brought out by a comparison of the coefficients of variability as recorded for series C on table 6 and for series B in table 3. All of the coefficients of variability are less for series C than those for series B, and in several instances indicate less variation of the microscopic "counts" than was

observed in the plate "counts" of series B. The average coefficient of variability for the group "counts" of series C is 11.7, while that for the individual "counts" is 13.4. These averages are decidedly better than the similar averages of 24.1 and 28.3 for series B. This improvement is undoubtedly to be charged to the greater skill of the analysts gained through their experience in the work of the previous series, and to the improved technique.

c. Comparison between the plate and microscopic counts

When the "counts" of series C as made by the two different methods are compared, the unique character of the results at once becomes evident. As already indicated, they meet the checks and counterchecks made upon their accuracy thus far discussed even more perfectly than those of series B.

They likewise very perfectly meet the test of comparison with each other, which is very severe in this case as the average number of individuals per group (1.45) was even less than before. However, in spite of this, every one of the final average plate "counts" as recorded in table 4 is intermediate in size between the group and individual "counts." Even the average "counts" as returned by the individual men showed only three of the group "counts" out of a possible 54 that were larger than the corresponding plate "counts," while only ten of the individual "counts" out of a possible 54 were smaller than the corresponding plate "counts" from the same samples. Moreover, eight of these were made by the one analyst (H) who, as already explained, evidently returned microscopic counts which were lower than they should have been.

Thus it becomes practically a certainty that there cannot be a large error in the final average figures, and that they actually show, in the one case, the number of groups originally present in the milk; in the second case, the number of centers of growth which existed after the partial distintegration of the clumps in the dilution waters; and, in the third case, the actual number of individual bacteria present.

Computation, based on the final average figures given in table 4, shows that, as in series B, the clumps were only partially broken apart in making the agar plates. Thus, whereas the average group of organisms in samples 2, 3, and 4 contained 1.47 individuals in the milk itself, the groups in the final dilutions used in making the plates contained 1.24 individuals. Likewise, whereas the original groups in the milk in samples 5, 6, and 7 contained 1.48 individuals, the groups in the final dilution water contained 1.25 individuals. In the third group of samples (8, 9, and 10), the average group in the milk itself contained 1.49 individuals, whereas the average group in the final dilution waters was reduced to 1.16 individuals. Thus, even under these very favorable conditions, the agar plate "counts" only approximate the number of bacteria present.

SERIES A. MISCELLANEOUS SAMPLES OF MILK

As this series of analyses has already been discussed in this journal (6) only brief reference will be made to it here. A summary of the results secured are given in table 8; while the detailed records appear in the bulletin by Breed and Stocking (10). From the detailed records it is possible to determine the causes of marked discrepancies in the plate and microscopic counts with a high degree of probability.

Sometimes the microscopic examination revealed the presence of masses of bacteria of such compact nature that they undoubtedly failed to break up completely. In other cases, the plates themselves gave evidence that some of the living bacteria had failed to develop into colonies. In general, however, it was the occurrence of the bacteria in groups which apparently caused the plate "counts" to be less than the probable number of bacteria present.

The average plate "counts" were larger than the group "counts" in 13 of the 21 samples (see table 8). In no case did the plate "count" exceed the individual "count" made from the same sample. Thus the plate "counts" ordinarily were intermediate in size between the two microscopic "counts," as was to be expected from theoretical considerations.

TABLE 8

Series A. Final summary of plate and microscopic "counts"

SAMPLE NUMBER	PLATE "COUNT"	GROUP "COUNT"	INDIVIDUAL "COUNT"	AVERAGE SIZE GROUP	NOTES
1	10,600	18,700	103,000	5.5	Herd milk
2	10,400	19,600	92,000	4.7	Herd milk
3-5	6,000	5,000	15,000	3.0	Herd milk
4	45,000	41,000	145,000	3.5	Herd milk
6	78,000	46,000	185,000	4.0	Market milk
7	72,000	47,000	202,000	4.3	Market milk
8	30,000	51,000	189,000	3.7	Market milk
9	98,000	80,000	383,000	4.8	Market milk
10	285,000	94,000	721,000	7.7	Market milk
11	52,000,000	93,000,000	99,000,000	1.06	Inoculated with long-rod, lactic acid organism
12	48,000,000	49,000,000	67,000,000	1.4	Inoculated with the colon bacillus
13	135,000,000	37,000,000	163,000,000	4.4	Fresh milk incubated at 37°C. for 24 hours
14	9,900,000	5,900,000	150,000,000	25.4	Market milk known to contain streptococci
15	2,000,000,000	1,500,000,000	2,700,000,000	1.8	Milk nearly curdled containing *Bact. lactis acidi*
16	121,000	60,000	387,000	6.4	Market milk
17	23,000	13,000	234,000	18.0	Market milk found to contain streptococci
18	1,900	12,000	34,000	2.7	Market milk
19	12,000,000	8,400,000	28,000,000	3.3	Market milk
20	5,600,000	5,200,000	26,000,000	5.0	Market milk
21	390	3,000	4,000	1.3	Milk from single cow
22	623	5,500	7,250	1.3	Milk from single cow

DISCUSSION AND CONCLUSIONS

The results secured indicate that skilled analysts, using proper technique, ordinarily obtain reasonably accurate estimates of the number of living bacteria in cubic centimeter samples of milk by the plate method *provided* the milk contains isolated organisms of a type capable of growth on agar under the conditions maintained.

They likewise indicate that estimates of the numbers of living bacteria and of the groups of bacteria can be made with equal accuracy by direct microscopic examination *provided* there are neither large clumps of bacteria nor dead bacteria present.

These statements are based on the fact that, under the favorable conditions maintained in series B and C, six analysts obtained "counts" or "estimates" of the number of bacteria from duplicate samples of milk by the use of the agar plate technique and by direct microscopic examination which showed good agreement among themselves, which had a coefficient of variability under 15, and which met all other checks upon their accuracy in such a way as to establish their true accuracy with reasonable certainty.

Because of the presence of clumps of bacteria, the agar plate "counts" were in each case less than the true number of individual bacteria present.

It being self evident that these accurate estimates were obtained under conditions much more favorable than those ordinarily present, the question naturally arises whether the inaccuracies in "counts" under ordinary conditions are sufficient to destroy the value of bacterial determinations. This question cannot be answered with entire satisfaction even with the data gathered in this and in previous investigations; but certain facts are evident as the result of the work done on the series of miscellaneous samples.

There has been a general feeling in the past that the errors in plate "counts," which were of the greatest significance were those introduced through the failure to prepare media of the correct reaction or composition, through the failure to use proper incubation temperatures, or through spreading colonies, overcrowding of colonies, and the like. Much attention has been given to the standardization of technique in order to reduce the known difficulties to a minimum.

Nevertheless, it does not seem probable that the errors caused by these things are so generally present or so irregular as those caused by the occurrence of the bacteria in groups of different average sizes. As it is clearly evident from series A, it is not at

all uncommon to find that one milk contains bacteria occurring in groups averaging two individuals per group, while another contains bacteria occurring in groups averaging four, six or even more individuals. Large errors in count caused in this way must be the rule rather than the exception. The latter errors could be eliminated if some method could be devised whereby the groups could be broken into their component individuals before the plates were prepared, and recent discussions of the plating technique emphasize the necessity of shaking the samples in a standardized way. Bacteria have so little weight, however, in proportion to their surface that hand shaking can have but little effect upon the compact groups.

The most disquieting feature of the errors introduced by the clumping of the bacteria is the fact that they may be highly variable, and yet pass undetected. It is reassuring to secure a series of plate "counts" from duplicate samples of milk which are in close agreement; and especially so if the analyses are made in different laboratories. However, the feeling that the "counts" are accurate passes away at once as soon as the microscopic studies are made, and it is found probable that some of the "counts" are affected by a 100 per cent error, others by a 200 per cent error, and still others by a 1000 per cent error, none of which are indicated in any way in the plate "counts."

It is natural to feel that a milk sample giving a plate "count" of 40,000 per cubic centimeter actually contains fewer bacteria than a milk sample giving a plate "count" of 50,000 per cubic centimeter. Yet comparative studies indicate that the chances are at least as great as one out of three that milk giving a plate "count" of 50,000 actually contains fewer bacteria than milk giving a plate "count" of 40,000. The chance that the lower "count" signifies larger numbers of bacteria becomes less and less as the margin between the "counts" becomes greater. If one can judge from the records already available giving the average size of the groups of bacteria in miscellaneous samples of milk, a margin of one to five makes it practically certain that the sample giving the larger "count" is actually from the milk containing the larger number of bacteria per cubic centimeter;

but even this margin does not appear to be sufficient to cover the errors introduced through the clumping of streptococci.

In contrast to these errors in plate "counts" caused by the difficulties involved in devising a perfect technique, the greatest difficulties met with in making accurate microscopic "counts" are those which involve the skill and patience of the analyst. Thus, in the present work, it was not until the last series of analyses were made that the men without previous experience realized these limitations of the microscopic technique, and not until then did the work of all the men begin to have precision and accuracy. In this series (C) the coefficient of variability of the microscopic "counts" was reduced to a figure comparable with that obtained from the plate "counts," i.e., less than 15.

Because the "counts" were made by two methods, it was ordinarily possible to detect conditions unfavorable to accurate work. Thus the microscope always showed what the conditions really were in regard to the size of the groups and the types of bacteria present, while the agar plates showed the number of centers of growth capable of development under the conditions maintained. Gross discrepancies in the "counts," not explainable through the presence of clumps, suggested the presence of dead bacteria, or of living bacteria not capable of growth on the plates. The fact that interpretations of this sort were possible shows that it would be an excellent practice for analysts to make "counts" of both sorts wherever especially accurate results are desired. Under such conditions care should be taken to make the "counts" by more precise methods than those used in ordinary routine work.

SUMMARY

1. Three series of bacterial counts from samples of fresh, unpasteurized milk have been completed. Six or seven analysts participated in each, working in two groups in laboratories located within fifty miles of each other.

2. In all cases, counts were made both by the agar plate method and by direct microscopic examination, thus permitting

a check upon the accuracy of the counts not possible where only one method of counting is used.

3. In two series (B and C), the samples analyzed were carefully prepared so as to present the most favorable conditions possible for accurate counting and to allow checks to be made upon the accuracy of the results. This was accomplished by inoculating three lots of freshly drawn milk known to contain very few bacteria, with a skim milk culture of the colon organism. The amount of inoculum used was such that the final counts were expected to show the ratio 1:2:4. The colon organism was chosen because it grows well under normal conditions, and exists in milk largely as isolated individuals.

4. Under the above conditions, the results met all of the checks upon their accuracy so perfectly that there can be little doubt but that they actually were fairly accurate counts of the number of individual bacteria present.

5. The results obtained in the final series (C) were so uniform that the coefficient of variability was reduced to less than 15 in all cases. Under the conditions present, the variability of the microscopic counts was slightly greater than that of the agar plate counts.

6. In the counts made from samples containing a miscellaneous flora (series A), wide variations were found between the plate and microscopic counts. The primary cause of these variations appeared to be the existence of clumps of bacteria which were not separated into their component individuals in preparing the agar plates. The uniformity of the agar plate counts was generally good, indicating that the technique used was satisfactory. The greater lack of uniformity in the microscopic counts was in part due to the inexperience of some of the analysts, several of whom had never before attempted to make accurate counts by microscopical methods.

7. The average number of individuals in the clumps of bacteria present commonly varied between two and six; but at times (when streptococci were present) greatly exceeded these numbers. As the data indicate that the clumps are only very poorly broken apart in the processes ordinarily used in preparing dilu-

tion waters, the plate counts did not represent the full number of bacteria present.

8. The chief limitations upon the accuracy of the microscopic counts appear to be those involving the skill of the analyst making the microscopic observations, and the patience necessary in order to examine a sufficiently large quantity of milk to give an accurate average. Given unlimited time, and numerous duplicate preparations from a sample of milk, a skilled microscopist can secure reasonably accurate counts of the number of individual bacteria present in any ordinary sample of milk. Yet the laboriousness of this proceeding limits its usefulness, and makes it impossible to actually count the bacteria in examining large numbers of samples.

9. Fortunately neither the inaccuracy of the plate counts caused by the clumping nor the limitations of the microscopic technique just noted, appear to be so great as to prevent the use of either technique where the purpose is to grade miscellaneous samples of unpasteurized milk into two or three grades. However, the information at present available indicates that attempts to use simplified methods for analysis for the purpose of making finer distinctions in quality introduces gross errors. When a finer classification is desired (as is now the case in many grade A plants) the use of the so-called simplified routine control methods should not be regarded as satisfactory. The present ituation suggests the desirability of the State exercising controls over bacteriological methods for analyses, whenever the results are to be used as a basis for payment in order to insure the use of more accurate methods of analysis just as it now does in the case of the Babcock test for determining the percentage of butter fat.

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OPEN FORUM

Should We Have a New Milk Score Card?

Score cards for butter and cheese have been in use for many years. Score cards for dairies were formulated almost simultaneously, in 1904, by Woodward at Washington and Pearson at Cornell University. These score cards were but the first of many. The flood gates of pent up enthusiasm for scoring opened, with the result that there were soon score cards for everything connected with the farm, including score cards for judging husbands and wives.

Recognizing the desirability of a uniform score card for dairy farms, the Official Dairy Instructors Association, or as it is now called, the American Dairy Science Association, appointed a Committee on Dairy Score Cards (1). This committee formulated, and in 1908 the Association adopted, the so-called Official Dairy Score Card, which has been widely used in the inspection of dairy farms. This score card is "Official" in the sense that it has been adopted by the Official Dairy Instructors Association and in many cities it is also "Official" in the sense that it has been legally made a part of the local health regulations.

A majority of the score cards of various kinds which have been proposed have been forgotten and the making of score cards has gone rather out of fashion. The score card for milk is an exception to this general statement. The milk score card was originally developed by the Federal Dairy Division for scoring bottles of milk in competition at various milk shows and it has undoubtedly served a useful purpose. This card is in a sense the property of the Federal Dairy Division and no one should question their right to continue it or change it as they see fit.

In 1919 (2), recognizing the increasing public interest in food value as an element of milk quality, the members of the Dairy Division decided to change their card by adding 10 points to those allotted to fat and solids not fat. To keep the total on the card at 100 points they subtracted these 10 points from the 25 formerly allotted to flavor and odor. This adaptation of the score card to changing conditions is commendable.

In order that they may be more readily discussed, both of the present milk score cards are reproduced in table 1.

One of these milk score cards has been in use for a number of years at the National Dairy Show. As a part of the educational work at the Dairy Show it has been the custom to stage a scoring contest in which teams representing Agricultural Colleges compete for medals and other prizes. The milk score card has been used in scoring the milk in this contest.

After the appearance of the revised milk score card, in August, 1919, a misunderstanding arose among the coaches of these teams as to which score card was to be used in the Dairy Show Contest. As a result some

TABLE 1

Present score cards for milk

	Perfect	
Bacteria	35	35
Flavor and odor	25	15
Visible dirt	10	10
Fat	10	15
Solids not fat	10	15
Acidity	5	5
Bottle and cap	5	5
	100	100

of the teams were at a disadvantage because they were trained in the use of one card and were compelled to compete in the use of the other.

Feeling the need of an official score card for milk, a committee on this subject was appointed in 1919 by the American Dairy Science Association. This committee recommended that the earlier form of Federal Milk Score Card be used in competitions for the year 1920 and at the recent annual meeting of the Association again recommended that the use of this card be continued for one year, pending their presentation in 1921 of a card for adoption by the Association. This leaves the matter of a milk score card before the Association without any prejudice as to the form of card to be later adopted, but makes it desirable that the members of the Association place their suggestions on this subject at the service of the committee.

The form of score card should depend primarily on the object to be attained through its use. The primary object of the card is to offer

a just basis for deciding which entry among those competing is the best milk. Back of the competition lies the desire on the part of the producer or dealer to gain favorable recognition for his dairy. The public quite uniformly consider that the winning of a prize in such a competition is evidence that the milk furnished by that dairy is of special excellence.

In addition to this primary aim of the card there is the possibility of developing a card which will accurately measure the real desirability of the milk. The real object of all attempts at safe-guarding public milk supplies is to find and encourage the production of high grade milk. If the quality of the milk as delivered to the consumer can be accurately measured by a score card, milk supervision can be largely reduced to establishing milk grades and to determining that the milk as delivered is sold in strict accordance with these grades.

The question of what are the elements, which taken together establish the quality of milk, was decided by the American Dairy Science Association when, in 1918, it adopted the report of its Committee on Milk Quality (3). This report stated that the quality of milk depends upon (1) food value; (2) healthfulness; (3) cleanliness; and (4) keeping quality. These qualities exactly parallel the oft repeated inquiries of the consumer: Is the milk rich? Is it safe? Is it clean? Is it sweet? If the score on a milk score card is to accurately measure the quality of the milk, the card must give due consideration to all of the elements of milk quality. In order to make plain the extent to which the present score cards do give such consideration, the score cards as shown in table 1 may be rearranged under the above four headings of milk quality. The cards so rearranged are shown in table 2.

The above table brings out the important and surprising fact that the present score cards entirely disregard the question of the safety of the milk. Under such conditions the gold medal may go to a highly dangerous milk supply. This entails not only an injustice to the competitors but also the added danger that the unsuspecting public, noting the receipt of this prize, may be stimulated to consume this dangerous milk. It should be noted that the public, by using their powers of observation, can reasonably assure themselves regarding the richness, cleanliness and sweetness of a milk supply but that they are practically helpless in attempting in this way to measure the safety of their milk supply. For this reason the Health Officials find their main problem the protection of the safety of the milk. On this account it is all the more surprising that the present milk score cards not only disregard

entirely the question of safety but actually mislead the consumer at the very point where he most needs help.

This entire omission of what many would consider the most important point in milk quality is not particularly evident from casual inspection of these cards because these cards blend together their results into a single score. Those familiar with milk will recognize that the presence

TABLE 2

Present score cards rearranged

	PERFECT	
Food value		
Fat	10	15
Solids not fat	10	15
Healthfulness		
Tuberculin test or pasteurization	0	0
Cleanliness		
Visible dirt	10	10
Bottle and cap	5	5
Keeping quality		
Bacteria	35	35
Flavor and odor	25	15
Acidity	5	5
	100	100

TABLE 3

Suggested score card for milk

DIVISION		PERFECT
I	Food value	
	Fat	15
	Solids not fat	10
II	Healthfulness	25
III	Cleanliness	
	Visible dirt	25
IV	Keeping Quality	
	Flavor and odor	15
	Bacteria	5
	Acidity	5
		100

When the score of each division is 20 or above the milk is *good.*
When the score of each division is 23 or above the milk is *excellent.*

of an unusual amount of one element of quality such as food value will not satisfactorily off-set either the presence of large amounts of dirt or the fact that the milk is sour. If any of the four elements of quality are distinctly deficient the milk must be considered as poor. On the other hand, if the milk scores high with regard to all four elements of quality the milk is good.

Accordingly it would seem that the two outstanding deficiencies of the present milk score cards were (1) the lack of proper attention to the safety of the milk; and (2) the failure to keep separate the score of each of the four distinct elements of milk quality.

It is rather easy to correct both of these weaknesses and an illustration of one method of doing this is given in table 3.

It should be clearly understood that the score card shown in table 3 is not offered as a perfect score card. It is presented in order to illustrate how, with the minimum change of the present card, the criticisms which have been raised against the present cards may be met.

The principle of recognizing divisions of the card, which divisions are considered separately in determining the quality of the milk, is neither new nor untried. It was one of the best features in the so-called Cornell Dairy Farm Score Card, devised by President R. A. Pearson and used successfully for some years by a number of municipalities (4).

The fundamental difficulty with the various past attempts at grading milk supplies has been the knowledge that the grades thus established were largely artificial and did not correspond with the real quality of the milk. If a milk score card can be agreed upon in which all the elements of milk quality enter proportionately, its application to the grading of milk is a short step and one which can be easily taken.

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H. A. Harding,
Department of Dairy Husbandry,
University of Illinois, Urbana, Ill.

HOT AIR STERILIZATION OF DAIRY UTENSILS

S. HENRY AYERS AND COURTLAND S. MUDGE

From the Research Laboratories of the Dairy Division, United States Department of Agriculture

INTRODUCTION

It must first be pointed out that when sterilization of utensils is under discussion, the term "Sterilization" is not used in a strict bacteriological sense. Normally, of course, sterilization means the complete destruction of bacteria, but as commonly applied in the dairy industry it means the results obtained by the use of steam at about 212°F. Steam at this temperature should destroy nonspore-forming bacteria, if applied for a sufficient length of time, but spores of bacteria are not destroyed.

This point should be kept in mind in connection with the use of hot air for the sterilization of utensils. Therefore, in order to devise a process for the sterilization of utensils by hot air comparable with usual steam sterilization it is necessary only to employ a temperature sufficiently high to kill nonspore-forming bacteria.

Hot air has been extensively applied for a long time for the sterilization of glassware in the laboratory. For this purpose a temperature of about 350°F. has been employed for a period of one and one-half hours. In this process the object is to completely destroy all living organisms, both spore formers and nonspore formers. In other words, this process effects a complete sterilization in the strict sense of the term.

It seems probable that the possibilities of hot air sterilization of dairy utensils have been overlooked because of the very high temperature and long heating period necessary for *complete* sterilization. Furthermore, the knowledge that moist heat is much more efficient as a destructive agent has led to the use of flowing steam for the sterilization of dairy utensils.

THE BACTERIOLOGICAL PRINCIPLES OF HOT AIR STERILIZATION OF DAIRY UTENSILS

Throughout this paper the term sterilization is not used in a strictly bacteriological sense but is used as in the dairy industry as previously explained. If it were necessary to use a temperature of 350° F. for one and one-half hours, the use of hot air would at once become impractical.

The air, however, need only be at a temperature sufficiently high to destroy non spore-forming bacteria when utensils are exposed to it for a given period of time. Naturally the lower the effective temperature and the shorter the length of exposure the more practical will be the process.

Since it is only necessary to accomplish by hot air the same results obtained by steam at about 212° F. a field of possibilities is opened up.

Before hot air sterilization can be properly applied it is necessary to know the effect of hot dry air on bacteria, since the primary object of utensil sterilization is one involving bacteriology.

The following points are considered in this paper:

1. Temperature of hot air and heating period necessary to destroy bacteria.
2. Hot air sterilization of cans, where cans can be held, as at dairy farms.
3. Hot air sterilization of cans, where process must be continuous, as in plants.

It is realized that the results presented do not solve all the problems of hot air sterilization. The practical application is an engineering problem which, however, must be based on data of the nature of the kind given in this paper.

TEMPERATURE OF HOT AIR AND HEATING PERIOD NECESSARY TO DESTROY BACTERIA

As early as 1881 Koch and Wolffhügel (1) showed that spore-free bacteria were destroyed at a temperature of a little over 212° F. when heated for one and one-half hours. Spore formers,

on the other hand, were not destroyed by three hours' heating at 284° F. Since that time other investigations have shown that to destroy microörganisms a higher temperature is required with dry heat than with moist heat.

Before experimenting with the sterilization of utensils with dry heat it was considered advisable to determine its effect on different bacteria, and studies were made of three organisms, B. coli, a heat resistant lactic type of bacteria which was not a spore former, and a typical spore forming organism.

The cultures were grown on agar, then suspensions of the growth were made in sterile distilled water. Previously, a number of large bore test tubes had been prepared by inserting in them a strip of tin through a cotton plug, and the whole sterilized in the dry oven. The sterile strips of tin were then immersed in the suspension of bacteria, replaced in the tubes, and allowed to dry at about 90° F. Care was taken that these strips did not touch the walls of the test tube.

These tubes were heated in an oil bath and the temperature of the air surrounding the strips of tin was determined by a thermometer placed in a control tube immersed in the bath.

In the first experiments, a heating period of thirty minutes was chosen because this is about the average steaming period for dairy utensils on dairy farms which are equipped with a sterilizer.

After heating, the tubes containing the infected strips of tin were allowed to stand until the air had cooled to room temperature, then they were removed and placed in tubes of sterile litmus milk. Complete destruction of the bacteria was determined by the absence of growth in the milk tubes.

The results in table 1 are of interest because they show that spore-free bacteria were destroyed at temperatures which were relatively low, particularly in comparison with dry heat laboratory sterilization.

As will be noted, about ten minutes was required to raise the air temperature to the desired point and it was maintained at the temperature for thirty minutes.

B. coli was destroyed after thirty minutes heating at 160° F. in one test. In a second test it survived 160° F. but was de-

stroyed at 180° F. The thermal death point of this organism when heated in milk for thirty minutes is about 140° F. It is evident, therefore, that it is somewhat more resistant to dry heat. The thermal death point of B. coli is slightly higher when heated in milk than nonspore-forming pathogenic bacteria, so it seems reasonable to assume, that their resistance to dry heat would be no greater than B. coli.

The heat resistant lactic type of organism, while not a spore former, withstood a higher temperature when heated in milk than B. coli, its thermal death point being 168° F. when heated

TABLE 1

The effect of exposing bacteria to dry heat at different temperatures for thirty minutes

TEMPERATURE HEATED AT	TIME REQUIRED TO HEAT AIR TO THIS TEMPERATURE	CULTURE KILLED		
		B. coli	Heat resistant lactic type	Spore former
°F.	*minutes*			
140	8	No	No	
160	8	1st test—yes 2d test—no	No	
180	10	Yes	No	
212	13	Yes	No	
221			No	
230	10		1st test—yes 2d test—yes 3d test—yes	No
250	7		Yes	No
270	10			No

for thirty minutes. It was realized that organisms of this type which are commonly found in milk would also be on dairy utensils and because of their high resistance to moist heat a higher temperature dry heat would be necessary for their destruction than was required for B. coli.

This proved to be the case, as shown in table 1. This lactic type survived heating at 221° F., but was destroyed in each of three tests when heated to 230° F. for thirty minutes. Other experiments showed that this organism was destroyed when held at 230° F. for ten minutes when the time required to reach this temperature was nine minutes.

The spore-forming organism was not destroyed even when heated for thirty minutes at 270° F. This temperature is probably about as high as could be practically employed. The fact that spore formers survive such high temperatures should be no hindrance to the development of hot air sterilization because these resistant spores would not be destroyed by the usual process of steam sterilization now employed in the dairy industry.

It seems, from these results, that to make hot air sterilization successful for dairy utensils a temperature of only 230° F. need be employed when it is maintained for thirty minutes. This heating period could be employed at dairy farms or at any plant where the sterilization of utensils does not have to be a continuous process. It is, of course, out of the question where utensils must be sterilized in large numbers in a short space of time.

This brings up the question of quick heating with hot air. From a few experiments, the results of which are shown in table 2, it is evident that when the heating period was reduced a higher temperature was required to cause a destruction of the organisms.

The experiments were conducted in the same manner as previously described except that the heating period was varied. Tubes containing the infected strips of tin were heated gradually and a tube was taken out every minute and examined for the effect of the temperature reached on the culture. B. coli when heated in two minutes to 167° F. was destroyed. Evidently a short heating period and a low temperature is effective. The heat resistant lactic type, however, was not destroyed when heated to about 255° F. in a period of six minutes. It was destroyed when heated in seven minutes to about 273° F.

In this connection it is of interest to observe that this organism was destroyed by heating for ten minutes at 230° F., but in this case the culture had been subjected to a nine-minute heating period while the air temperature in the tube was being raised from room temperature to 230° F. This emphasizes the fact that there is a time and temperature factor to be considered.

It should be remembered that the method of determining the effect of heat in these experiments measured the absolute thermal death point of the organism, that is, the temperature at which every cell was destroyed. It is very probable that long before the temperatures cited were reached the majority of the bacteria were killed. In fact only a few cells may have resisted the highest temperature. This point is important in connection with the practical application of hot air sterilization.

TABLE 2

Effect of heating bacteria rapidly in dry air

HEATING PERIOD	HEATED TO	CULTURE KILLED	CULTURE
minutes	*°F.*		
1	129.2	No	B. coli
2	167.0	Yes	
3	194.0	Yes	
4	212.0	Yes	
5	224.6	Yes	
1	149.0		Heat resistant lactic type
2	195.8		
3	224.6	(Heated to 255.2°F. in 6 minutes.)	
4	240.8		
5	248.0		
6	255.2	No	
1	147.2		
2	197 6		
3	228 2	(Heated to 273.2°F. in 7 minutes.)	
4	249.8		
5	264 2		
6	269.6		
7	273.2	Yes	

HOT AIR STERILIZATION OF CANS, WHERE CANS CAN BE HELD AS AT DAIRY FARMS

From the data obtained in the experiments previously reported it seemed evident that on theoretical grounds, at least, good results could be obtained in utensil sterilization by an exposure to hot air at 230° F. for a period of thirty minutes. A process of this nature should be practical for use on dairy farms or any place where there is plenty of time for sterilization.

Experiments were, therefore, conducted with the sterilization of cans under laboratory conditions. An apparatus was constructed which consisted of a gas oven with a fan inside so arranged that it would blow air into an inverted can. Heat was supplied by a gas burner beneath the oven so that any desired temperature could be maintained. Determinations were made of the time required to heat the air in the can to the desired temperature with the fan running at a definite speed and the air entering the can at a known temperature. From these figures it was possible to place cans in the apparatus and heat them to any temperature desired and hold them for any length of time.

The cans used in the experiments were filled with milk which was allowed to sour in them. Sometimes cream was used in place of milk. The three 4-quart cans which were employed in each experiment were handled in the same manner except that two were sterilized for different lengths of time and the third was kept for a control. It was washed the same as the other two but not sterilized. The cans were washed in water at about 112° F. so as not to give a very efficient washing and to avoid destroying any bacteria through heat. No washing powder was used and the cans were not rinsed at all carefully. In fact the drippings from the cans when they went into the hot air sterilizer were milky. This type of washing was purposely employed in order that the cans would be in a condition worse than would normally be encountered. It was felt that if efficient sterilization could be obtained by hot air treatment with the cans in the condition as used in these experiments, then successful results could surely be expected under commercial conditions where the cans would be more thoroughly washed.

After sterilization, the cans were examined for bacteria by rinsing with 100 cc. of sterile water and plating. The bacteria in the control unheated can were determined in the same manner.

From the figures shown in table 3, it is evident that efficient sterilization was obtained when cans were heated for thirty minutes at 230° F. Six minutes was required to raise the temperature of the air in the can to this point. Heating for only fifteen minutes caused a very great reduction in bacteria but the

results were not so uniformly good. It should be noted that the figures represent the number of bacteria per 4-quart can and not the number on the plates.

In one experiment cream was allowed to sour in the cans for four days. In this case, as will be noted, special methods were used to detect yeasts and molds. The yeasts were destroyed at both holding periods and for practical purposes the same might be said of the molds. The numbers of the organisms being 200 and 100 per can represent two and one colonies on each plate.

TABLE 3

The destruction of microörganisms in milk cans by exposure to dry air at 230°F.

SERIES NUMBER	CONTENTS OF CAN BEFORE WASHING	NUMBER BACTERIA PER CAN		
		Washed	Heated 15 minutes	Heated 30 minutes
1	Sour milk	3,400,000,000	100	100
2	Sour milk	510,000,000	300	100
3	Sour milk	3,600,000,000	300	400
4	Sour milk	760,000,000	1,800	600
5	Sour milk	1,080,000,000	500	800
6	Sour cream	222,000,000	400	400
7	Sour milk	1,400,000,000	800	200
8	Sour milk	1,570,000,000	1,500	200
9	Sour milk	1,500,000,000	4,000	200
10	Sour milk	3,110,000,000	4,200	400
11	Sour cream, 4 days old	1,100,000,000	21,700	400
11		Yeasts: 18,000,000 Molds: 7,000,000	Yeasts: 0 Molds: 200	Yeasts: 0 Molds: 100

These might easily have been contaminations which are commonly observed in these laboratories. In all the experiments the cans were completely dry after the heating process. They dried very rapidly when the air temperature reached 212° F.

It is believed from these results that hot air at 230° F. for a period of thirty minutes can be used satisfactorily for the sterilization of dairy utensils. Moak (2) reports the use, with excellent results, of dry heat for sterilization on a certified milk farm. From his paper it seems that a temperature of about 270° F. was employed for two hours. The results of our experiments

indicate that it is not necessary to use such high temperatures and that thirty minutes' heating is sufficient. This would naturally reduce the cost of the sterilizing process.

HOT AIR STERILIZATION WHERE PROCESS MUST BE CONTINUOUS AS IN MILK PLANTS

The application of hot air sterilization in plants where a large number of cans have to be handled in a short time presents an entirely different problem from that of the dairy farm. In this case it is a question not only as to whether it is possible to obtain a satisfactory sterilization in a few minutes but also whether it can be done on a practical scale. Only the first problem will be considered in this paper, namely, is it possible to sterilize cans by hot air in a few minutes time?

From results reported earlier in this paper it was evident that if the holding period was reduced the temperature must be raised. Acting upon this information the temperature first used was 248°F. Cans were treated in the same manner as when held for thirty minutes at 230° F., but in this series of experiments the air in one can was raised to a temperature of 248° F. in four minutes and the other can, heated to this temperature in the same length of time, was held at it for two minutes. The unheated control can was treated as usual.

The results in table 4 show that a great destruction of bacteria took place when the air in the cans was raised from about 112° F., the temperature after washing, to 248° F. in four minutes but the results were not uniformly low. When held two minutes, making a total heating period of six minutes, much better results were obtained. In one experiment it was found that the yeasts were destroyed and the molds practically so.

The results obtained with the four-minute heating and two-minute holding periods were not as good as those obtained when a temperature of 230° F. was employed and maintained for thirty minutes. It must be remembered, however, that the cans were in an extremely bad condition and this heating process might prove satisfactory if the cans were properly washed.

Another series of experiments was conducted, using an air temperature of 266° F. In this case the time required to heat the air in the cans to this temperature was five minutes. One can was merely raised to 266°F. and the other held two minutes

TABLE 4

The destruction of microörganisms in milk cans by exposure to dry air at 248°F.

SERIES NUMBER	CONTENTS OF CAN BEFORE WASHING	NUMBER BACTERIA PER CAN		
		Washed.	Heated to 248° F. in 4 minutes	Heated to 248° F. in 4 minutes and held 2 minutes
1	Sour milk	51,000,000	300	300
2	Sour milk	17,300,000	6,200	3,700
3	Sour milk	33,000,000	2,000	300
4	Sour milk	1,050,000,000	700	100
5	Sour milk	1,540,000,000	241,000	90,000
6	Sour milk	600,000,000	1,100	500
7	Sour milk	1,310,000,000	3,200	100
8	Sour milk	1,280,000,000	15,600	400
9	Sour milk	2,500,000,000	54,900	900
10	Sour milk	98,000,000	600	0
11	Sour cream, 4 days old	370,000,000	1,600	1,000
11		Yeasts: 1,290,000 Molds: 550,000	Yeasts: 0 Molds: 100	Yeasts: 0 Molds: 100

TABLE 5

The destruction of bacteria in milk cans by exposure to dry heat at 266°F.

SERIES NUMBER	CONTENTS OF CAN BEFORE WASHING	NUMBER BACTERIA PER CAN		
		Washed	Heated to 266° F. in 5 minutes	Heated to 266° F. in 5 minutes and held for 2 minutes
1	Sour milk	5,700,000,000	1,000	600
2	Sour milk	2,300,000,000	3,600	100
3	Sour milk	2,400,000,000	700	300
4	Sour milk	1,280,000,000	7,800	100
5	Sour milk	2,100,000,000	13,300	900

at this point. Here again, as may be seen from table 5, the effect of the two-minute holding period could be observed and the results were very satisfactory.

One more series of experiments was tried in hopes of being able to reduce the heating period to four minutes by increasing

the temperature. In these experiments a temperature of 284° F. was employed and the air in one can was raised to this point in four minutes. Another can was heated in the same time and held two minutes at this temperature.

The results in table 6 show that in both cases good reductions were obtained, although here again the value of the two-minute holding period at 284° F. was manifest. The greater efficiency

TABLE 6

The destruction of microörganisms in milk cans by exposure to dry air at 284°F.

SERIES NUMBER	CONTENTS OF CAN BEFORE WASHING	NUMBER BACTERIA PER CAN		
		Washed	Heated to 284° F. in 4 minutes	Heated to 284° F. in 4 minutes, then held 2 minutes
1	Sour milk	450,000,000	2,000	100
2	Sour milk	730,000,000	200	300
3	Sour milk	900,000,000	200	200
4	Sour milk	410,000,000	700	200
5	Sour milk	660,000,000	1,000	600
6	Sour milk	1,010,000,000	1,900	200
7	Sour milk	2,100,000,000	500	100
8	Sour milk	1,260,000,000	2,400	700
9	Sour milk	1,390,000,000	400	400
10	Sour milk	530,000,000	400	700
11	Sour cream, 5 days old	960,000,000	400	300
11		Yeasts: 1,900,000 Molds: 4,000,000	Yeasts: 0 Molds: 100	Yeasts: 0 Molds: 100

of 284° F. over 248° F. is shown by comparison of the bacterial reductions in tables 4 and 6. This is particularly true when the air in the cans was merely heated to the temperatures indicated. In all the experiments the cans came out perfectly dry.

An interesting point is indicated by the results of these experiments, namely, that to obtain effective sterilization a certain minimum length of exposure seems to be necessary. While the holding period can be reduced as the temperature is increased there seems to be a point beyond which the increase in temperature does not permit of a proportionate decrease in the holding period.

SUMMARY

1. The destructive effect of hot air on various types of bacteria is shown.

2. A temperature necessary for effective sterilization of utensils has been determined which seems to make the process of hot air sterilization practical for dairy farms or plants where utensils can be held.

3. The temperature of hot air necessary to cause sterilization in from four to six minutes has been determined.

4. No definite facts have been presented to show the value of hot air sterilization from a practical standpoint. The results merely point out some of the fundamental facts upon which rest the commercialization of the process. This is an engineering and economic problem.

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A RAPID ACIDITY TEST FOR GRADING MILK[1]

ROSCOE H. SHAW

Research Laboratories, Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.

Some time ago the author was called upon to devise a quick acidity test for use in the condensery department of the Grove City, Pa., Creamery. A test was required that could be used in the receiving room to indicate whether a certain can or lot of milk was within a fixed limit in acidity. The ordinary method of titrating with $\frac{N}{10}$ alkali is entirely too slow for the purpose. The test herewith described was in successful use for several years and is presented with the thought that it may be useful to others having similar requirements. No special originality is claimed for the two small dippers, since it is understood that somewhat similar dippers have been in use for some time in certain establishments.

Two small dippers of equal capacity and preferably of brass are required, one for measuring the milk and the other for measuring the special alkali solution. Fifteen or 20 cc. is a convenient size. The one for milk should be provided with a handle long enough to reach down into a milk can, while the handle of the other should be about 6 inches long.

The special stock alkali solution contains 17.777 grams of sodium hydroxide per liter[2] and is of such strength that when 50 cc. of it is diluted to 1 liter with distilled water, making what may be termed the working alkali solution, unit volume of the latter will exactly neutralize the acid in unit volume of milk of 0.2 per cent acidity. This working alkali is a flexible one. It can be adjusted for any desired acidity of milk by simply using more or less of the stock alkali solution when making it

[1] Published by permission of the Secretary of Agriculture.

[2] This solution must be carefully prepared. Since sodium hydroxide absorbs moisture from the air, it cannot be made by simply weighing out 17.777 grams, dissolving, and diluting to one liter. If a chemist is not available the solution should be purchased from a reliable chemical or creamery supply house.

up. For example, if it be desired to have the working solution of such strength that unit volumes of it and 0.22 per cent acidity milk will neutralize, then instead of diluting 50 cc. of stock solu-

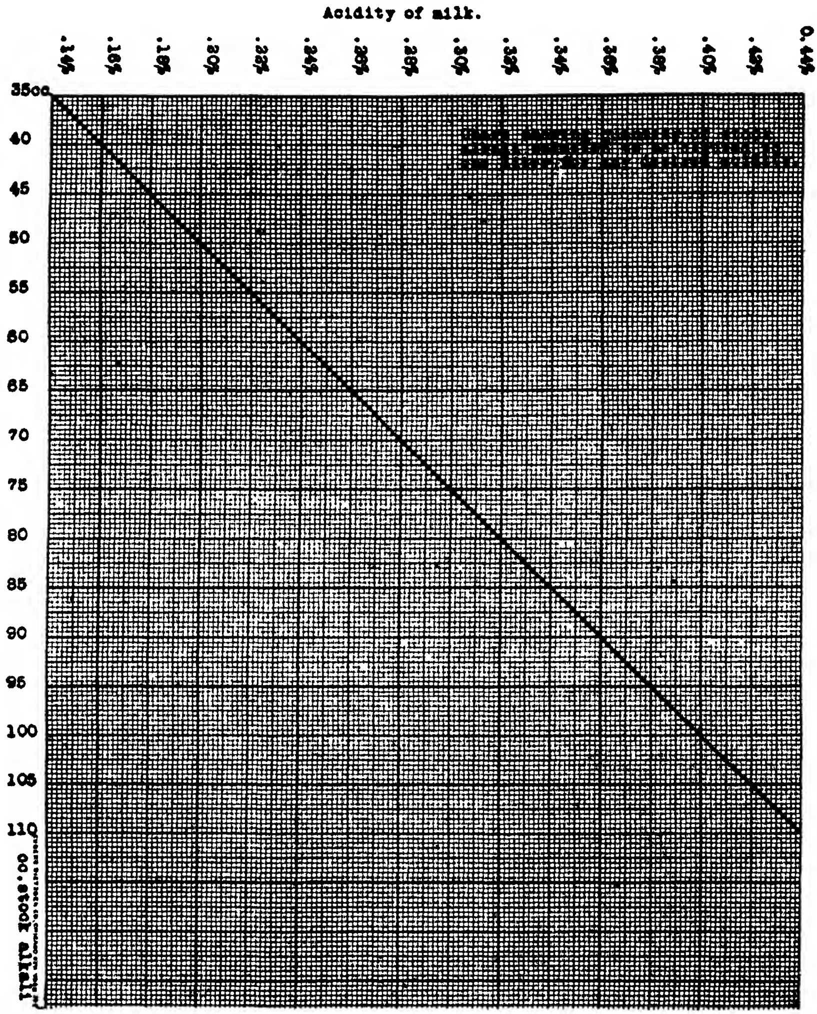

CHART 1

tion 55 cc. would be used. The accompanying chart shows the quantity of stock solution to be diluted to one liter for any desired acidity of milk.

In preparing the working alkali solution the proper quantity of the stock alkali solution should be carefully measured from a burette into a liter volumetric flask and then distilled water at room temperature added to the mark. Shake the mixture well. For convenience it can be poured into a large beaker into which the brass dipper can easily be submerged. Only enough of the working alkali solution for one day's run should be made up. If any is left it should be thrown away.

The manner of using the test will at once be apparent. Simply lower the milk measuring dipper into a can of milk and pour contents into a white cup or white enamelled dipper. Add a few drops of phenol-phthalein solution (1 per cent in alcohol). Now pour in a dipperful of the working alkali solution and mix by pouring into another white cup or enamelled dipper. If the working alkali solution was prepared for 0.2 per cent acidity milk then the milk will remain pink if it is less than 0.2 per cent acidity and it will become colorless if it is 0.2 per cent or more. Perhaps a better way is to add the indicator to the working alkali solution while making it up. If this is done enough should be added before making up to the mark to color the solution an intense pink. The amount to use can be learned only by experience, but 2 cc. of the phenol-phthalein solution is suggested.

It is suggested that the test be checked up with the titration method before it is relied upon finally, for it must be remembered that the personal equation plays an important part in testing milk for acidity. To some eyes milk will have a decided pink tint, while to others it will appear colorless. It must also be taken into account that the working alkali solution is dilute (about $\frac{N}{45}$) and four or five drops will be required to produce the same color change that one drop of $\frac{N}{10}$ alkali will produce. Consequently it is quite possible that with milk testing 0.19 per cent or even 0.18 per cent acidity the special test will show a colorless milk to some operators when it should show a pink tint. In such cases it will be necessary to increase the strength of the working alkali solution until it does react at 0.2 per cent acidity. If this be done a proportionate increase must of course be made for all other acidities.

The stock alkali solution is rather concentrated and unless care be taken the glass cock in the burette will stick. It is not advisable to let the alkali solution remain in the burette after using. It is best to pour what remains back into the bottle and rinse out the burette with water.

In testing cream for acidity it will be necessary to rinse out the dipper with water and add the rinsings to the charge. Cream, being more viscous than milk, will adhere more to the walls of the dipper.

PERFORMANCE IN SOME OF THE LEADING GUERNSEY SIRES

DEVOE MEADE

Department of Animal Husbandry, University of Maryland, College Park Maryland

INTRODUCTION

The continuous improvement of the herds of live stock in the country depends upon the elimination of the unfit and the selection for mating of those individuals which possess in the highest degree the desirable character sought and which are still further endowed with the power to transmit their qualities to their offspring. Two things are therefore necessary to be determined in the systematic selection of animals and in the improvement of breeds. First, it must be determined which are the superior individuals of the breed and second, so far as possible, it must be ascertained with what degree of force and uniformity these animals transmit their productive qualities and capacity. Especially is this true of the sire since the relative influence of the male, because of his opportunity, is so much greater than is the influence of any single female.

In order that one may obtain the greatest success in breeding dairy cattle, it is necessary that he should have some definite plan of breeding, some definite method by means of which males and females, especially the former, may be selected. Some means should be provided whereby the leading productive strains may be located and their prepotency, so far as concerns production capacity, indicated by some measurable quantity. It was with the idea of studying the transmitting power of some of the leading Guernsey sires that this work was undertaken. It is intended to continue this research so as to include a similar study of the transmitting power of these bulls through their sons' daughters. This paper is therefore presented not as a concluded work but as a report of work still in progress.

MATERIAL

All Guernsey bulls having 25 or more daughters in the Advanced Registry up to July 1, 1918 were studied. To this list of bulls was added Ne Plus Ultra because of the present strong demand for his progeny and also because of the fact that he was owned by Mr. S. M. Shoemaker of Eccleston, Maryland, one of the leading Guernsey breeders of the state. Altogether 14 bulls were included in the study. The following is an alphabetical list of the bulls regarding which data were collected. The number preceding the name of the bull indicates the number by which that bull should be known throughout this discussion. The first number following the name of the bull is his herd book number. The number in parenthesis designates the number of Advanced Registry daughters which he has. Following this is the date of birth:

1. Cora's Governor of Chilmark (Imp) 8971 (40)..........May 5, 1903
2. Galaxy's Sequel (Imp) 16904 (40)....................June 12, 1904
3. Glenwood Boy of Haddon 4605 (26)..............February 11, 1895
4. Glenwood's Main Stay 6067 (26)......................May 13, 1899
5. Golden Noble II R. G. A. S. 1836 P. S. (26)....November 21, 1905
6. Governor of the Chene R. G. A. S. 1297 P. S. (76)..September 5, 1900
7. Justinee's Sequel of the Preel R. G. A. S. 2119 P. S. (35) September 26, 1907
8. King of the May (Imp) 9001 (25)..................February 6, 1903
9. Lord Mar (Imp) 14359 (27)............................May 10, 1905
10. Masher R. G. A. S. 63 F. S. (31).......................May, 1904
11. Masher's Sequel (Imp) 11462 (68)....................April 14, 1900
12. Ne Plus Ultra 15265 (20)............................June 23, 1909
13. Prince of Groton 9841 (26).......................December 18, 1902
14. Princess's Jewel (Imp) 25877 (28)..................January 6, 1906

Of these 14 bulls 10 were bred on the Island of Guernsey. Six have been imported. Nine of these bulls belong to four great Guernsey families, namely, Governor of the Chene, Masher, Glenwood Girl, and May Rose. The daughters of these 14 bulls have 631 advanced registry records to their credit. The calculations herein contained, therefore, include 631 individual butter fat records.

METHOD

It is coming more and more to be recognized that dairy bulls should be selected on the basis of performance, rather than upon some other abstract quality. While no definite standard for measuring performance has yet been uniformly adopted, it is, however, very generally agreed that performance in the bull should be measured by his ability to endow his daughters with the power of high milk or high butter fat production or both.

A number of different methods of expressing the relative productive capacity of bulls have been used at different times. Among such methods the following may be enumerated:

1. The total number of advanced registry daughters which a bull has.
2. The number of daughters that a bull has that have exceeded some arbitrary high production standards, such as 500 or 600, pounds of butter fat per year.
3. The number of daughters equivalent to 1000, 800, 600 etc., pounds of butter fat per year calculated on the basis of the yearly advanced registry requirements for the class or age.
4. The percentage production of all advanced registry daughters based upon the standard advanced registry requirements according to age.

The first method of comparison is open to the very serious criticisms that both the age and the opportunity of the bull which very materially effect results are not taken account of.

Methods two and three are open, in a degree, to somewhat the same objections as method one. These methods are also objectionable because of the fact that emphasis is placed upon extreme variation in production rather than upon high average yield. By calculating the results secured in methods two and three in terms of percentage of total number of advanced registry daughters which are high producers, we may, in a measure, eliminate the effects of age and opportunity but too much emphasis is still placed upon the upper extremes of production.

The fourth method takes into consideration the production of every tested daughter thus eliminating the effects of age and

opportunity. This method also has an added advantage over the others in that it points out the bulls whose daughters have the highest average of production. The most valuable bull from the standpoint of breed or herd improvement is not the bull that is the sire of a few exceptional individuals, the remainder of his female offspring being perhaps inferior, but it is the one whose daughters are possessed, on the average, of the highest degree of production. The fourth method of comparison is the system followed in this study as it is felt that this method is more free from criticism than the others.

DISCUSSION

The daughters of each bull were grouped, following the Guernsey Advanced Registry Classification, into their respective age classes. Table I gives the Age Classes with their respective age limits together with the standard production requirement assumed for each class.

TABLE 1

CLASS	AGE LIMIT	YEARLY BUTTERFAT REQUIREMENT
A	5 years or over	360.0
B	4½ to 5 years	341.8
C	4 to 4½ years	323.5
D	3½ to 4 years	305.3
E	3 to 3½ years	287.0
F	2½ to 3 years	268.8
G	Under 2½ years	250.5

An example will serve to illustrate the method of calculating the rate of production per individual based on the standard requirement for the class. If a cow under two years and six months of age produces 501 pounds of butter fat per year her percentage of production is 200 $\left(\frac{501}{250.5} \times 100\right)$. The average percentage production of each bull is obtained by getting the average percentage production of all his daughters.

In any method of comparison there is no possible way of eliminating or measuring the effects of factors such as the quality

of cows with which the individual bulls were mated, the environmental conditions under which the tests were conducted, the production of untested daughters or of tested daughters who failed to make at least the minimum advanced registry requirements set by the Association. It is unfortunate, but of necessity it is true, that this or any similar study must be made of a more or less selected population. Any method of comparison to be absolutely comparable would require that all bulls under

NUMBER OF BULL	NUMBER OF RECORDS	PER CENT VALUE	A		B		C		D		E		F		G	
			Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1	52	160	6	183	3	177	6	162	4	143	5	149	7	140	21	164
2	49	151	15	143	1	128	2	158	8	152	7	161	12	155	4	147
3	48	153	13	147	3	171	3	146	5	144	4	218	5	127	15	155
4	45	137	9	147			4	132			3	154	3	115	16	134
5	38	168	17	155	3	171	2	168	6	186	2	216	4	170	4	167
6	101	158	27	140	10	141	11	147	13	152	8	145	13	155	19	159
7	38	151	4	132	3	118	3	104	5	146	7	166	7	151	9	167
8	30	211	7	185					2	222	2	194	3	234	16	218
9	39	160	5	125	2	142	6	182	5	144	5	186	6	160	10	155
10	32	128	9	136	2	131	2	123	5	151	8	115	6	117		
11	83	139	32	138	4	121	4	132	13	138	8	137	18	155	4	134
12	28	193	1	190	1	180	1	202	3	170	3	195	5	202	14	196
13	29	128	23	126	2	137			2	135					2	143
14	33	148	10	148	2	119	5	154	2	143	4	142	4	140	6	166
Average	631	158	178	144	36	144	49	153	63	176	66	158	93	155	136	171

consideration be bred to the same cows and that all offspring be reared, developed and tested under the same environmental conditions, which obviously is impossible.

Table 2 gives the number of records obtained by the daughters of each bull, the average percentage production of all of the daughters of each bull and the average percentage production of the daughters of each bull by age classes. At the bottom of the table is given the average percentage value of each class. This value was secured by taking a weighted average.

Arranging the 14 bulls in descending order according to the average percentage production of their daughters, they rank as follows:

8.	King of the May	211
12.	Ne Plus Ultra	193
5.	Golden Noble II	168
1.	Cora's Governor of Chilmark	160
9.	Lord Mar	160
6.	Governor of the Chene	158
3.	Glenwood Boy of Haddon	153
7.	Justinee's Sequel of the Preel	151
2.	Galaxy's Sequel	151
14.	Princess's Jewel	148
11.	Masher's Sequel	139
4.	Glenwood's Main Stay	137
10.	Masher	128
13.	Prince of Groton	128

King of the May, the percentage production of whose daughters is 211, heads the list. King of the May is followed by his grandson Ne Plus Ultra whose value is 193. Golden Noble II comes third with a value of 168. Governor of the Chene, who has more daughters in the Advanced Registry than any other Guernsey Bull, stands sixth. Masher's Sequel, who for a long time ranked first in the number of advanced registry daughters, stands eleventh.

An inspection of table 2 will show that cows in classes "A" and "B" have lower percentage values than cows in the other classes. The data here presented would tend to indicate that it is hardest for mature cows and senior four years olds and easiest for senior three and junior two year olds to meet or exceed the present advanced registry requirements of the breed. The mature cows and senior four years olds exceed the requirements by only 44 per cent whereas the senior three year and the junior two year olds exceed the standard by respectively 76 per cent and 71 per cent. Consequently, those bulls having a large proportion of their tested daughters in classes "A" and "B" are at a distinct disadvantage when the present standards of fat production are the basis of comparison.

While the data presented in table 2 is too limited in amount to permit of the drawing of any definite conclusions, the indications are, taking the average percentage production of each age class as the basis of comparison, that the present standard requirements of the breed associations are not comparable for all age classes. For example: Classes "A" and "B" each exceed the standard requirement by only 44 per cent whereas Classes "D" and "G" exceed the standard by 76 per cent and 71 per cent respectively. If the present standard requirement of 360 pounds of butter fat for the mature class is maintained, the

TABLE 3

BULL	A		B		C		D		E		F		G	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1	6	11.5	3	5.8	6	11.5	4	7.7	5	9.6	7	13.5	21	50.0
2	15	30.6	1	2.0	2	4.1	8	16.3	7	14.3	12	24.5	4	8.3
3	13	27.1	3	6.3	3	6.3	5	10.4	4	8.3	5	10.4	15	31.3
4	9	25.7			4	11.4			3	8.6	8	8.6	16	45.7
5	17	44.9	3	7.9	2	5.3	6	15.8	2	5.3	4	10.5	4	10.5
6	27	26.7	10	9.9	11	10.9	13	12.9	8	8.0	13	12.9	19	18.8
7	4	10.5	3	7.9	3	7.9	5	13.2	7	18.4	7	18.4	9	23.7
8	7	23.3					2	6.7	2	6.7	3	10.0	16	53.3
9	5	12.9	2	5.1	6	15.4	5	12.9	5	12.9	6	15.4	10	25.7
10	9	28.1	2	6.2	2	6.2	5	15.6	8	25.0	6	18.8		
11	32	28.6	4	4.8	4	4.8	13	15.7	8	9.6	18	21.7	4	4.8
12	1	3.6	1	3.6	1	3.6	3	11.7	3	11.7	5	17.9	14	50.0
13	23	79.3	2	6.9			2	6.9					2	6.9
14	10	33.3	2	6.7	5	15.2	2	6.7	4	12.1	4	12.1	6	18.1

requirement for the other age classes are undoubtedly all too low, and, in order to place all age classes on an equal basis, should be increased. Further study, however, is necessary to accurately determine what the standard of the age classes should be.

In determining the respective productive capacity of two or more bulls, both the average percentage production and the distribution of his daughters as to age classes should, therefore, be taken into account.

Table 3 gives the number and percentage distribution of the daughters of each bull according to age classes.

Bull no. 8, King of the May, has 63.3 per cent of his daughters in classes "F" and "G." Bull no. 12, Ne Plus Ultra, has 67.9 per cent of his daughters in the same two classes. These two bulls head the list. Bulls no. 10 and no. 13, who are at the bottom of the list have only 18.8 per cent and 6.9 per cent respectively in classes "F" and "G." On the other hand, respectively 34.3 per cent and 86.2 per cent of their daughters are in classes "A" and "B." It will be seen from the data here presented that there is quite a wide variation in the percentage distribution of

TABLE 4

Percentage distribution of the records of the daughters of the 14 bulls

NUMBER OF BULL	NUMBER OF RECORDS	100 TO 120 PER CENT	121 TO 140 PER CENT	141 TO 160 PER CENT	161 TO 180 PER CENT	181 TO 200 PER CENT	201 TO 225 PER CENT	226 TO 250 PER CENT	OVER 250 PER CENT
1	52	7.7	21.2	25.0	15.4	21.2	9.6		
2	49	12.2	30.6	24.5	16.3	10.2	6.1		
3	48	14.6	27.1	25.0	20.9	4.2	2.1	2.1	4.2
4	35	25.7	28.9	25.7	17.1			2.9	
5	38	7.9	21.1	10.5	28.9	5.3	18.4	5.3	2.6
6	101	16.2	27.3	26.3	26.3	4.0	1.0	1.0	
7	38	15.8	21.1	21.1	21.1	10.5	7.9	2.6	
8	30		6.6	3.3	6.6	16.6	33.3	16.6	16.6
9	39	10.3	17.9	28.2	20.5	12.8	7.7	2.6	
10	32	50.0	25.0	9.4	12.5	3.1			
11	83	20.5	31.3	20.5	13.3	7.2	2.4		
12	26		3.6	3.6	25.0	28.6	28.6	7.2	3.2
13	29	31.0	44.9	24.1					
14	33	15.2	27.3	36.4		3.3	3.3	3.3	

the daughters of different bulls in the several age classes. However, considering this diversity of distribution in conjunction with the differences in percentage productions of daughters, it is doubtful, so far as these 14 bulls are concerned, if the rank of the bulls on the percentage production of daughters only would be materially changed.

Table 4 gives the percentage of the records of the daughters of each bull falling within the several production groups, each group being based upon the percentage by which the records of the daughters exceed the breed standard.

Of the 52 records of the daughters of bull no. 1, 7.7 per cent have exceeded the breed standard by 100 to 120 per cent; 21 per cent by from 121–140 per cent; 25 per cent from 141 to 160 per cent, etc. Only four of the 14 bulls have produced daughters exceeding the breed requirements by over 250 per cent. The most frequent distribution is found in the group 121 to 140 per cent. On the average, 23.8 per cent of the records fall in this group. 20.2 per cent of the records fall in group 141 to 160 per cent and 18.7 per cent fall in group 161 to 180 per cent. Therefore, 62.7 per cent of all records fall in these three groups.

SUMMARY

There are a number of different methods available for studying the performance or productive capacity of bulls, taking the production of their daughters as a basis for comparison. The method which appears to be the most free from criticism is to make a comparison using as a measure of performance the percentage production of all advanced registry daughters based upon the standard advanced registry requirements according to age.

There is a great difference in the production capacity of bulls as indicated by the records of their daughters. King of the May and Ne Plus Ultra have performance records of respectively 211 per cent and 193 per cent while Masher and Prince of Groton [illegible] formance records of only 128 per cent. The average pr[illegible] daughters of all bulls is 158 per cent.

It is to be p[illegible] be selected upon the basis of his performance as ind[illegible] duction capacity of his daughters rather than upo[illegible] or lineage. Individuality and lineage indicate wha[illegible] ity of a bull may be; performance is a measure of wh[illegible] y is. The ideal combination is, of course, excellent individu[illegible] strong ancestry, and superior performance. It is hardest for cows in classes "A" and "B" and easiest for cows in classes "D" and "G" to meet or exceed the advanced registry requirements. Cows in classes "A" and "B" exceed the requirements by only

44 per cent whereas the cows in classes "D" and "G" exceed the requirements by 76 per cent and 71 per cent respectively.

Owing to the fact that the present breed requirements for the various age classes are not entirely comparable, the apparent productive capacity of a bull should be considered with reference to the distribution of his daughters in the various classes.

The largest proportion of the records made by the daughters of the 14 bulls falls within the groups producing from 121 per cent to 180 per cent production based upon the standard requirement for the breed. Approximately 63 per cent of all records fall within these groups.

ACIDITY AND QUALITY

F. W. BOUSKA

American Association Creamery Butter Manufacturers, Chicago, Illinois

Methods of making butter are the result of ideals and conditions. Originally butter was made on the farm. As enough cream to make a churning was being accumulated it soured spontaneously. About one-half of our butter supply comes from cream soured and churned on the farm. The other half is made in creameries and also from sour cream. The majority of this cream is also soured on the farm.

Buttermaking is the pioneer dairy industry. Concentration of population in large cities forces the butter territory farther away. The vicinity of Elgin no longer produces butter. Its dairy product is sold as market milk. New York City reaches 400 miles for market milk and cream and many so-called "creamery" in New York state is only a milk and cream shipping establishment. Cheese factories, condenseries, and milk powder plants crowd the butter maker farther and farther from the large consuming centers. Since these dairy plants can pay a better price they choose the best developed territory with the best volume. Thus the creamery is always the vanguard of dairy manufactures. Early writers on American dairying regarded it confined to a "Dairy Belt" lying between the fortieth and forty-fifth parallels and the Atlantic Ocean and Missouri river. This strip is north of Columbus, Ohio, and south of St. Paul, Minn. In the last ten years the relative increase in production of creamery butter has been much greater outside of this "Dairy Belt" than within it. Inability of production of butter to keep up with the increase in population has crowded buttermaking into less favorable territory and into hands of farmers who never before were creamery patrons.

Not only was the butter produced near the points of consumption but our grandmothers brought it directly home as purchased. It did not have to make a round trip of the city

in a delivery wagon. More of it went directly from the farm to the consumer. Now wholesalers of butter and the rapidly growing chain stores prefer butter whose uniformity and keeping quality are dependable.

A generation ago there was a surfeit of butter in the summer and a butter famine in the winter. Now cold storage tends to equalize these extremes.

In the meantime the cost of farm labor has risen to such a figure that the farmer carefully considers where to apply his labor and whether to employ outside labor.

The foundation of a creamery is an economic one. It persuades the farmer that it can make better butter and cheaper than he can. The creameries have convinced the farmers furnishing butterfat for the 600,000,000 pounds of creamery butter that this is true. Creameries are going into the remotest corners of the land and striving to convince the farmers making 900,000,000 pounds of farm butter that it would be better for them to shunt this work upon the creameries.

Hence, the following facts stand out prominently:

1. Marketing at long range and cold storage created a new requirement for butter: Keeping quality. This is appreciated more and more.

2. Taking possession of the best dairy territory by more intensive dairy manufactures and the increasing cost of farm labor have made it more difficult to care for cream and more difficult to deliver it frequently.

3. Increasing scarcity and the rising price of butter have caused creameries to solicit cream wherever it may be found. Creameries propogandize for more cows, better cows, better fed cows, and better quality of cream.

High cost of labor is rapidly forcing wholemilk creameries to give way to cream creameries. Even in Minnesota, the field of the wholemilk creameries, they are a small minority. Cream produced on farms furnishes practically all of our butter supply. A large part of this cream is received sour. All creameries want good cream. They would rather have the cream sweet. They make great efforts to improve the quality of cream. Education,

persuasion, and prices are available as means for bringing about improvement. Good sour cream makes ninety point butter. If the bulk of sweet cream butter scored 93, it would be doing better than it is doing. This improvement in quality usually brings two cents a pound more for the butter and sometimes three. Assuming that a cow produces one-half pound of butter-fat daily the extra pay for better care and for going to town before the cream sours, say every day or every other day, is 4 cents a day for four cows; 40 cents a day for ten cows; 80 cents a day for twenty cows.

It is obvious that the question whether the increase in price is a sufficient inducement depends on the size of the herd. Many states average less than four cows per farm. Clubbing or the operation of routes in those localities where it is feasible greatly increases the premium available for sweet cream. Paying a better price for better cream is economically and morally right.

A small volume of dairy butter sells at fancy prices, say a dollar a pound, and some creamery butter is reported to bring premiums as high as ten cents a pound. Every creamery that can sell its butter at this advantage should do so and we are told that the supply of this butter is not equal to the demand. I believe that the number of consumers who will pay ten cents more than the prevailing price is very small. Indeed, the rich people who have been eating oleomargarine for patriotic reasons or to help bring down the price of butter are much more conspicuous. I have never seen any fancy priced butter on sale in Chicago. I have eaten at most of the public eating places in America. I am seldom served with fancy butter. It is usually good ordinary butter.

Butter possessing good keeping quality is preferred by buyers. If it does not have keeping qualities its flavor is uncertain and cannot be uniform. Butter that remains eatable for two weeks at approximately 65° or for four to six months in cold storage is a good keeper. The following are requisites for good keeping: (1) Low acidity, (2) pasteurization, (3) elimination of butter-milk, (4) proper working.

Butter from the freshest and sweetest cream does not keep well unless pasteurized. Even if sweet and pasteurized it does not keep well if overworked or if the buttermilk is not well eliminated. Thus in spite of supposedly good material much butter keeps poorly. The economic and hygienic need of pasteurization is obvious.

If sour cream is pasteurized the butter has a scorched flavor, a high curd content, the loss of fat in churning is heavy (often 3 per cent) and often the cream curdles or becomes ropy. In fact, heating sour cream makes cottage cheese out of it but the curd is usually so finely divided that it is not visible. The curd adheres to the plastic butter granules thus giving the butter a high curd content. Fat globules are imprisoned in this cottage cheese and thus a large loss of fat in the buttermilk occurs.

The pasteurization of sour cream causes so much difficulty and loss that it is impractical as a general program. Reducing the acidity with limewater alleviates these difficulties. As the acidity is depressed lower and lower these difficulties lessen. They are practically eliminated when the acidity is lowered to 0.25 per cent to 0.35 per cent (14° to 20° Manns').

Naturally, lime for neutralizing cream should be as pure as possible. The usual impurities are sand, clay, and iron. The first two leave characteristic settlings after slaking. The iron gives the unslaked lime a reddish color. Poor results from lime are much more often due to improper making up than to chemical impurities. Improper mixing produces a granular mixture which imparts to butter a great deal more limey taste than a smooth mixture. This is very noticeable in hot weather when cream is very sour.

The following method produces a smoother lime mixture than any other method we have ever seen: Take 17 pounds of water as hot as you can get it and add to it 3 pounds of powdered or lump quicklime. Do not put this all in at once but add it in four installments with thorough stirring between. Reversing the method and adding water to lime or adding all lime at once is very likely to produce a granular mixture. When cool the mixture is judged by stirring and then dipping into it the hand

to the wrist and observing the smoothness of the mixture on the palm of the hand. If it is smooth like milk it is a good mixture; if two or three particles smaller than pinheads are visible it is a fair mixture; if the palm shows many particles like cottage cheese it is a poor mixture. Cream is neutralized before it is heated much to such an acidity that it has 0.25 per cent to 0.35 per cent (18° to 20° Manns') after pasteurizing. Pasteurization lowers the acidity more or less.

If the cream is to be ripened again the acidity is usually reduced to 0.16 per cent to 0.22 per cent (9° to 12° Manns') and then ripened to about 0.5 per cent (29° Manns').

The best way is to put the cream in a supply vat or forewarmer and then cut the acid to the desired point.

The action of lime is very slow and plenty of stirring and time should be given before concluding that more lime is needed. If the acidity after pasteurizing is too high it should be cut down before starter is added, or before churning.

The more cream is heated before neutralizing the larger the loss of fat in buttermilk. Many losses are caused this way. Some heating is of course necessary to insure mixing. Not much harm is done by holding less than one hour at 90° or a minute or so at 120°. Any temperature above 90° is liable to increase losses if prolonged. The lower the temperature and shorter the time the better.

Any quantity of mixture can be prepared by multiplying the above proportions (17 and 3) by a suitable factor. Five times gives 85 + 15 = 100. This is a 15 per cent mixture. A richer mixture is usually more granular. A thinner one is seldom smoother and is more bulky.

Hydrated lime is preferred by some. It is made up by mixing with cold water to a consistency of rich milk or 15 per cent. If uniformly made up this mixture has uniform strength but is somewhat more gritty.

Either mixture may be used as soon as well mixed or when smooth or the next day.

It is known that 0.3114 pound of dry quicklime neutralizes 1 pound of lactic acid. Hydrated lime is lump lime to which some water has been added. We have found it to contain from 11 per cent to 14 per cent water. Although different brands of hydrated may vary in water content the same brand probably does not vary much and has uniform strength.

Although the best limes do not contain 100 per cent calcium oxide, they usually contain enough magnesium oxide to make up for this and their neutralizing power is close to 100 per cent. If the lime has say 90 per cent neutralizing power as shown by a practical trial in cream, the mixture can be made 10 per cent stronger to fit the table. The greatest obstacle to the use of a table is the drop in acidity caused by pasteurization. This varies with cream, lime, and locality. A user may offset this in the makeup of his limewater. This is always easier to do than to construct a new table. By changing the strength of the limewater this same table can be used to reduce to other acidities, e.g., 0.25 per cent or 0.35 per cent.

When sour cream containing 0.7 per cent of lactic acid is neutralized to 0.4 per cent one is surprised to find that after pasteurization the acidity is only 0.3 per cent or perhaps as low as 0.2 per cent. The sourer and more gassy the cream the more granular the lime, or the more carbonic acid in the sodium carbonate used the greater the drop in acidity produced by pasteurization. It is impossible to foretell in North Dakota what the drop will be in Oklahoma and vice-versa. The extent of the decrease can be ascertained only in the creamery in question.

The loss in acidity brought about by the heating is caused by expulsion of volatile acids, by a more intimate union of limewater and lactic acid, and by expulsion of carbonic acid. Carbonic acid cripples the sensitiveness of the indicator (phenolphthalien). Hence a determination of acidity in raw sour cream is only approximate and reads too high.

Some find a neutralizing table convenient in determining the amount of limewater to be added to cream. The following table is suggested for that purpose.

To reduce acidity to 0.3 per cent

CREAM	INITIAL ACIDITY OF CREAM										
	0.35	0.40	0.45	0 50	0 55	0 6	0.65	0.7	0.8	0.9	1 0
	Pounds of 15 per cent lime water needed										
pounds											
50	0.05	0 1	0 15	0 20	0.26	0 31	0 37	0.41	0.50	0 62	0.72
100	0.10	0 2	0 31	0 41	0 52	0 62	0.73	0 83	1 03	1.24	1.45
500	0 51	1 03	1 55	2.07	2 59	3.11	3 62	4 14	5.18	6.22	7.25
1,000	1.03	2 07	3 11	4 14	5 18	6 22	7.25	8.29	10.37	12.44	14.51
1,500	1 54	3.10	4 66	6 21	7 77	9 33	10.88	12.43	15 55	18.66	21.77
2,000	2.07	4 14	6 22	8 3	10 37	12 45	14 51	16 58	20 74	24.89	29.04
2,500	2.57	5 17	7 77	10 35	12 95	15 55	18 14	20 72	25.92	31.10	36 29
3,000	3.11	6 21	9 33	12 42	15 54	18 66	21 77	24 89	31.11	37.33	43.56
3,500	3.61	7.24	10.88	14.51	18.14	21 78	25 39	29 01	36 29	43 55	50 81
4,000	4 15	8 29	12.44	16 59	20 74	24 89	29 03	33 19	41 48	49 78	58.07
4,500	4 64	9 31	13 99	18 65	23 32	28 00	32 65	37 30	46 66	55.99	65 33
5,000	5.18	10 37	15.55	20.74	25 92	31 11	36.29	41 48	51 85	52 22	72 59
6,000	6.22	12 44	18.66	24.89	31 11	37 33	43 55	49 78	62 22	74 67	87.11
7,000	7.25	14.51	21 77	29 03	36 29	43 55	50 81	58 08	72 59	87.11	101.63

Because of this drop in acidity, a neutralizing table may not always be practical. One trying this table better do so with the consideration that it may not be dependable in his case until verified by actual trial; this notwithstanding that the table is chemically and mathematically correct as far as it goes.

Another fairly accurate procedure is as follows: The quantity of cream and strength of limewater are not known. The acidity is tested and found to be say 0.65 per cent. A measure of limewater is added and reduces the acidity 0.04 per cent or down to 0.61 per cent. Then the total excess acidity is 0.61 per cent − 0.3 per cent = 0.31 per cent. The quantity of lime required to reduce from 0.61 per cent to 0.3 per cent will be 0.31 ÷ 0.04 × measure = 7¾ measures. Of course measures also means pounds.

Butter from unneutralized sour cream homogenized with sweet milk yields sweet cream. The lactic acid is in the buttermilk. Indeed the majority of bad flavors are in the buttermilk and not in the butterfat. It is very important to wash the butter quite freely from butter ilk. The more thoroughly this is

done the less off flavor the butter will have. The butter is churned quite cold into granules the size of wheat up to small peas. If larger, or if soft, the buttermilk is sealed in the granules. When the buttermilk is draining a stream the size of the thumb the granules and churn are well rinsed with the hose or a shower bath sprinkler. This crowds out the buttermilk. Then the bunghole is closed and the butter washed in the usual way.

Lactic acid has a much stronger affinity for lime than any other cream constituent. Under these circumstances lime does not act on the butterfat nor any other constituent. It is all taken up by the lactic acid and 0.3 per cent of the lactic acid remains unsatisfied. In the draining of the buttermilk and the washing of the butter the great majority of the lime is eliminated. This is a good reason why butter from neutralized cream often contains less lime than country butter. The cause of this is that buttermilk has not been well eliminated out of the country butter. Lime is a natural constituent of milk and cream being combined with casein. Butter from neutralized cream usually contains from .04 per cent to .07 per cent lime. Unneutralized creamery butter has about the same percentage. In country butter the lime content is sometimes just as low, but in high casein butter the percentage of lime is sometimes 0.11 per cent.

A portion of neutralized butter contains 0.05 per cent or 0.007 grams of lime; a teaspoonful of limewater contains 0.019 grams of lime; a quart of water from a limestone country 0.100 grams; a quart of milk 1.36 grams. A baby often gets a teaspoonful of limewater in a feed of milk. Our mothers gave it and physicians recommend it. An adult would have to eat 1.46 pounds of neutralized butter to ingest as much lime as the bably consumes in one feed of milk.

Lime is an essential constituent of foods. Lack of it causes "lime starvation" and physiological disorders. Two investigators not only recommend but insistently urge the addition of lime to the daily diet. (Calcium Salts as Body Builders, page 372 Review of Reviews, Sept., 1912.)

On page 78 of his "Food Products," Dr. Sherman of Columbia University thus states the need of lime:

> Calcium is present in still greater relative abundance. Milk contains slightly more calcium, volume for volume than does limewater. As a rule the calcium content of the diet depends mainly upon the amount of milk consumed. In family dietaries where ordinary quantities of milk are used, the milk is apt to furnish about two-thirds of the total calcium of the diet. Without milk it is unlikely that the diet will be as rich in calcium, as is desirable whether for the child or for the adult.

Hence, neutralizing cream is not injurious to health.

Neutralization does not abstract any constituent of cream or butter; it does not cheapen its composition or manufacture; it does not lessen its food value. On the contrary, it improves the flavor and keeping quality.

I do not aim to give the impression that all cream offered to centralizers is faultless. I frankly say that a small fraction is contaminated with foreign materials or stale. Such cream is condemned by the buttermakers or by the local food authorities. I strive to make clear the fact that these defects occurred upon the farm and that such cream is offered to creameries operating under every system. I maintain that it is not fair to pillory the whole industry because of the poor condition of one can of cream out of thousands of cans of good cream. Farmers offer or ship their cream to the creameries and the creameries do not know the quality of this cream until it is inspected at the creamery. Creameries welcome honest constructive efforts to improve butter.

Neutralization of cream reduces its acidity, makes possible pasteurization without scorched flavors and excessive losses of fat in the buttermilk, and thus improves the keeping quality of such butter. Neutralization is not a cure-all for stale cream, rancid cream, feed flavors nor any other defects that afflict cream and butter. Neutralization does not enable a creamery to make good butter out of poor cream. Poor cream always makes poor butter.

THE MILK SITUATION IN ONTARIO

J. A. RUDDICK

Dairy Commissioner, Ottawa, Ontario

The milk situation in Ontario as in the whole of Canada, or in any other country with an exportable surplus of dairy produce, is bound up with the international or world's situation. Local conditions may affect the situation temporarily but with improved storage and transportation facilities, and the extension of commercial organization the upward or downward curves of prices or stocks in any one country are sooner or later flattened out to the general level of the world's markets and requirements. This rule applies more strictly to butter and cheese and other manufactured products than it does to milk itself for the reason that milk does not, strictly speaking, enter into international commerce. Fundamentally, however, the price obtainable for milk is based on the export value of the manufactured product. It follows if the price of cheese or butter is high that the milk distributors must pay a correspondingly high price to secure supplies and on the other hand the price of milk falls in sympathy with a drop in the export value of the surplus of the manufactured products.

This point would seem to be too obvious to need elaboration, and yet there are a large number of otherwise well informed people in this country who cannot understand why dairy products should not be cheap just because milk is plentiful and feed abundant in their particular locality. They are inclined to make sarcastic remarks about the law of supply and demand and the ugly word "profiteer" is too frequently used in this connection.

What these people fail to see is that the law of supply and demand as applied to dairy products operates on a world wide basis and is not very materially affected by conditions in Canada or in any other country. If there is an unusually large production in Canada or New Zealand or any other part of the world, the increase is such a small percentage of the total world's supply

as to be more or less negligible. Furthermore, it usually happens that if production increases in one part of the world it drops somewhere else. The total carry over from one season to another is flexible enough to act as a further regulator.

This world wide basis for the dairy produce trade tends also to preserve an even balance between the different products and prevents overproduction of any single article. A knowledge of world conditions is useful in this connection. That is why the writer has made considerable study of this sort of thing for some years past and has endeavored to disseminate reliable information on the subject.

The stability given to prices by the conditions above outlined are of great value to producers of milk. It prevents the wide price fluctuations which other food products are subject to, the prices of which are determined by supply and demand over limited areas or for which there is no export demand.

Take potatoes for instance. The price was high in 1919 because the short crop was not equal to the local demand and not being an article of international commerce, because of their great bulk in proportion to value and relatively high transportation charges, importation could not be relied upon to make up the deficiency. In 1920 with an excess of supply, which could not be relieved by exportation, prices fell to an unprofitable level.

Or again, take the fruit trade as an illustration. The price of apples in this country depends largely on the demand in the United Kingdom, while the price of small or tender fruits is regulated by local supply and demand. Apples were in good demand for export and brought high prices in 1920, while on the other hand the small fruits of which there was a bigger crop than usual were for some varieties almost a drug on the market. These are important considerations and deserve the attention of both producers and consumers.

Now, of course, the war completely destroyed for the time being the extensive and complicated agencies which are necessary to keep the trade in dairy products running evenly and efficiently. It disorganized transportation, and diminished the

stream of supply from some quarters and completely dried up others. Difficulties of finance, and government purchase and control interfered with private trading. Prices were held up in some cases and kept down in others. An abnormal demand led to overproduction of some products in the end. The whole situation became demoralized, at times exasperating and always very difficult. More recently the varying rate of exchange has created many anomalies.

There is now a loss on the export of Canadian produce, while there is none on shipments from Australia and New Zealand. Denmark has been selling butter to the United States where it is not needed, but simply because the exchange rate was so favorable that it could be landed in New York at less cost than butter could be bought on that market, and at the same time bring a better return to the Danish exporter than he could obtain in England where the selling price is much higher than it is in the States. This state of affairs will continue until there is complete decontrol in the United Kingdom and exchange rates get back to something like parity all round.

As for the matter of control it is well for the sake of clearness to state just what it is at present.

All cheese now being imported into the United Kingdom is free. There is a comparatively small stock of so-called "government" cheese still on hand which comprises the remainder of last year's purchase of Canadian and some New Zealand cheese secured under the contract which expired in August last. This cheese is retailed at 40 cents per pound.

Imported butter is still under control and is rationed at 2 ounces per head per week. So far as I know the only butter contracts now running are those with New Zealand and Australia and these expire on March 31 next. The Chancellor of the Exchequer recently announced, in the House of Commons, that the Ministry of Food would be disbanded at the end of March and it is thought that will be the last of food control in the Old Country, for the present at any rate.

Of course, they have the right to manage their own affairs but the continued control has been the cause of a great deal of

irritation and dissatisfaction which is not lessened any by the fact that their home production has been free for some time and brings a higher price than that which is imported.

As to when the rate of exchange may come back to a parity I am, of course, not able to offer an opinion.

Imports of cheese into the United Kingdom during the past year have exceeded the prewar figures. The principal sources of supply for this article were not interfered with during the war and production was stimulated in some quarters by the high prices. Then again, the large accumulation in New Zealand was brought forward so that receipts from that source have been abnormal. The increased receipts have been met it is said by a very large increase in consumption of cheese in England owing to the high price of meat and increased purchasing power of certain classes of the people.

On the other hand supplies of butter are still far below normal as is indicated by the ration of 2 ounces per week. It so happened that the chief sources of butter supply were either entirely cut off or very seriously diminished. Russia which was second only to Denmark as a butter exporting country before the war has not supplied any worth mentioning since 1915. Production in Denmark is recovering, but a considerable proportion of it has been sold to Germany and other continental countries to say nothing of the shipments to the United States.

Denmark has of late been increasing her shipments to England at lower prices than those obtainable on the Continent, because the prudent Dane knows that the only permanent market of the future will be that of the United Kingdom and he does not care to run the risk of losing it through a little temporary advantage.

Now, when we come to consider market prices in the United Kingdom we are faced with another anomaly. With the drop in prices which we have had in this country and the United States there would seem to be ample justification for the view that the market is lower than it has been, but as a matter of fact prices are higher now in the Old Country than they were at any time during the war or since. I realize that there is cold comfort in this fact for the dealer who can't get more than 48 cents for

his export butter or for the producer who is offered 10 cents less for his output than he got at one time during the summer. It is, however, a fact of some importance, that while prices for other food products have fallen those for dairy produce are still at the maximum in the market which is practically our sole dependence for our exportable surplus and the state of which normally determines prices in this country.

The explanation which is offered is not wholly satisfactory to me but I give it to you for what it is worth.

To go back a little you will probably remember that the British Ministry of Food had a two year contract with New Zealand and Australian producers, which expired in August last, to take their butter at about 38 cents and cheese at 21½ cents F.O.B. shipping point. A new contract was made for butter only, which expires on the 31st March, at 60 cents F.O.B. (280 shillings per 112 pounds). We are told that this butter costs laid down in England 297 shillings per cwt. (112 pounds). There is no loss on exchange. The pound sterling is worth as much in New Zealand or Australia as it is in England, and it is the currency of these countries. New Zealand cheese is free like Canadian.

Last September and October at the openi
some cheese sales were made for season's outpu
cents F.O.B. steamer but a large quantity is being consigned for sale in England, and past experience proves that whenever there is a large quantity coming forward in this way that it has a depressing effect on the market.

When these New Zealand contracts were completed it was announced that the agent of the Ministry of Food in Montreal would buy Canadian butter at a price that would permit of it being laid down in England at the same net cost as the New Zealand. It was even announced that an extra 3 shillings a cwt. would be paid for Canadian butter. Control butter is retailing in England at 80 cents per pound (three shillings and four pence) and British made butter which is free was quoted wholesale in the *Grocer* of December 10 at 400 shillings per cwt. (over 85 cents).

Now, of course, in figuring the cost of Canadian butter laid down in England there must be added to the price paid in Canada the freight and handling charges and, unfortunately, also the loss on exchange which is the big item at present. Even so, I confess that I am unable to understand why the margin between the retail price in England and the Ministry's price in Canada should be so wide, and on the face of it there would seem some justification for the claim that if butter was fully decontrolled a higher price could be obtained for Canadian as in the case of the home production. There are some, however, who take the view that decontrol might bring out such quantities of United States butter as to have the opposite effect. There is undoubtedly a large surplus in that country, which has been increased by the influx of 15,381,954 pounds of Danish.

Those who hold this opinion point to the effect of decontrol on the Canadian cheese market. It is a fact that the price of cheese is lower now than it has been for several years, yet the retail price in England was never as high as it is at the present moment. There is this difference, however, between cheese and butter, as has already been mentioned, that supplies of cheese are fully up to normal while butter is still far short of the requirements. It is certain, however, that the removal of control would receive universal approval, and though there is bound to be a period of readjustment, the market will never reach a state of equilibrium while this artificial condition exists.

Now, I haven't said much so far about the milk situation in Ontario. It is not necessary to say much, because the matters which I have been dealing with are the factors that control the general situation. Whatever the situation may be here it is only a symptom of a world wide condition.

I would, however, like to make a few remarks concerning the position in which a large number of producers found themselves when the condensed milk and milk powder business backed up on them last fall. No matter what the producers may have felt at the time, or may still feel, about it, the fact remains that in the case of condensed milk, at least, it was the inevitable result of the war production which was greatly in excess of peace

time requirements. The crisis, if we may call it such, was probably precipitated by the financial situation, including exchange, and the drop in the price of sugar. But there is no use of crying over spilled milk. The thing to do is to take a lesson from the experience.

Producers should not in these days be placed in a position of dependence on any single outlet for the disposal of their milk. The ideal arrangement, wherever it is possible, would be to have a receiving depot, preferably under the control of the producers, equipped to manufacture cheese and butter, and in large establishments possibly condensed milk or milk powder, and for the sale of milk or cream. The idea has been tried out at the Finch Dairy Station, operated by the Dominion Dairy Branch, with what success I will leave it with you to judge.

The Station was started in 1912. It is located at the crossing of the Ottawa branch of the New York Central Railway and the Montreal-Toronto line of the Canadian Pacific Railroad. The train service is such that the morning's milk or cream can be delivered by noon in either Montreal or Ottawa. The Station is equipped for the manufacture of butter or cheese and for the shipping of milk or cream, pasteurized or not as may be required, but in either case well cooled.

Cheese factories surround the Station on all sides and there is a condensory at Chesterville 10 miles away.

That the patrons have been satisfied with the returns is indicated by the fact that the quantity of milk received annually has increased from 2,069,281 pounds in 1912, to 5,570,545 pounds in 1920. I have been informed that not a single individual milk or cream shipment leaves the Finch railway station, although it is well within the area from which supplies are drawn for Montreal and Ottawa.

The following table gives the record for the nine years of operation.

It will be noticed that there has been an increase in the number of patrons especially during the last two years, but these are mostly winter patrons who come in for a few weeks after surrounding factories close. We have not encouraged patrons to leave competing factories during the summer months.

TABLE 1

YEAR	NUMBER OF PATRONS	MILK RECEIVED	NET RETURN TO PATRONS PER 100 POUNDS	TOTAL AMOUNT DISTRIBUTED TO PATRONS
		pounds		
1912	60	2,069,281	$1.11	$23,304.49
1913	60	2,720,028	1 04	28,214.73
1914	64	2,356,202	1.19	28,108.74
1915	65	2,418,010	1 35	32,640.85
1916	54	2,486,380	1.60	39,779.88
1917	65	2,807,885	2 00	56,173.46
1918	75	3,859,217	2.14	82,785.69
1919	100	5,480,816	2.49	136,540.56
1920	112	5,570,545	2 49	138,792.89
		29,768,364		$566,341.29

The record for 1920 showing the disposal of the milk and rate per 100 paid to patrons month by month may be of interest and help to bring out my point. Here it is.

TABLE 2

Disposal of milk and returns to patrons by months, Finch Dairy Station, 1920

MONTH	CHEESE	BUTTER	MILK SOLD	FAT SOLD AS CREAM	RETURN TO PATRONS PER 100 POUNDS
	pounds	*pounds*	*pounds*	*pounds*	
January			153,216		$3.50
February			107,238	1,272	3.22
March			94,911	7,316	2.70
April		3,441		13,751	2.37
May	12,322	483		20,399	2.49
June	2,395			30,933	2.38
July	33,950	768		13,822	2.24
August	15,703	4,736	32,240	9,540	2.28
September	5,591	9,258		9,367	2.45
October	3,846	1,765	20,000	11,985	2.63
November			31,120	10,040	2.72
December				8,778	2.70
Totals	73,807	20,451	438,725	137,203	
Average for year					$2.492
Total milk received (pounds)					5,570,545

In case you may think that the patrons of the Finch Station have some special advantages in low manufacturing charges or other bonus let me say that they have none whatever. They get a good service for which they pay full rates. It is a strictly commercial proposition, and any advantage there is in it comes through good business management and being in a position always to sell the product for which there is the best market at the time.

The charges for manufacturing are $2\frac{1}{4}$ cents per pound for cheese and 5 cents for butter; for handling milk 12 cents per hundred pounds is charged and for cream 4 cents per pound of fat.

In operating the Station the management makes no lengthy contracts. Prices are determined week by week. The quantity of milk or cream shipped is varied or shipments stopped entirely at a day's notice. Milk distributors can afford to pay, and do pay, a premium for milk under an arrangement of this kind because they avoid surpluses, on which there is always a loss.

I do not offer this plan as a solution for all the producers' difficulties, or as one suitable for general adoption. I am aware that there are many localities to which it would not be adaptable. I see no reason, however, why it could not be followed in many places where there are good shipping facilities or where milk could be sold to condensories or powder factories. The condensor at Chesterville has been a good customer of the Finch Station. It is along similar lines that the Fraser Valley (B. C.) Milk Producers are working, and I believe that organization is the most successful of all similar organizations in Canada.

If a number of establishments like the Finch Station were in operation in Western Ontario they would undoubtedly have a steadying influence on the milk situation as a whole. I have not consulted the milk condensing or milk powder people in the matter, but I see no reason why it would not suit them to secure supplies of milk through such a source, if not regularly at least in times of extra demand. In case a market should be found for all the milk as such the organization would be continued and ready to deal with the milk in some other fashion in case of need.

It is admitted that the most serious aspect of the milk situation which developed when the demand for condensed products fell off last fall, was the closing of the old cheese factories, with their equipment scrapped, even the buildings gone in some instances, the staffs of experienced makers dispersed, and the organization completely broken up.

If I were planning such an establishment, I would make the manufacture of cheese or butter the sheet anchor of the business, and then sell as much milk or cream as I could find a market for at higher prices.

We need never be afraid of serious over-production of either cheese or butter. The market for all we are likely to make is waiting for us, and in the case of cheese at any rate we can command the very top price in the world's markets.

The newer knowledge of nutrition which is being disseminated throughout the world today is a great boost for milk and its products. Even already the signs are not lacking that milk, butter and cheese are being placed higher in the scale of dietary values than they have been in the past.

We may not always get as much for it as we think we are entitled to but it does appear as though dairy produce would bring as high, if not a higher relative price, than most other farm products. Look at the situation today with the price of many products dropping but with cheese and butter still at the peak in the market where prices are determined.

SOILING VERSUS SILAGE FOR DAIRY COWS UNDER NEBRASKA CONDITIONS[1]

J. H. FRANDSEN, J. W. HENDRICKSON, G. C. WHITE,[2] A. C. NORTH[3] AND E. G. WOODWARD[4]

Nebraska pastures do not generally furnish enough feed for dairy cows during the dry, hot summer months. In view of this fact it is generally recognized by dairymen, especially those on high-priced land, that the pastures must be supplemented either by the use of summer silage or by a system of soiling.

The use of either the silage or the soiling system results in an increase in the number of cows that may be kept on a certain piece of land. Both systems are conducive to the greater production of milk and butter fat.

The soiling system easily adjusts itself to conditions where labor is cheap and plentiful and where land is high. In European countries where these conditions prevail soiling has been practiced more widely than in America. However, with the increase in population and the limited area for expansion America may be approaching a condition of intensified agriculture that requires the greater use of soiling crops as a supplement if not as an exclusive summer feed for dairy cows.

Soiling is the growing and supplying of fresh forage to animals kept in confinement. It does not mean, however, that grain is not fed in connection with the forage. This system is generally practiced where intensive farming is carried on and where market milk is in demand. It enables the stockman to concentrate his capital and labor while maintaining a number of animals on a comparatively small acreage of land.

If soiling is to be successful, there should be sufficient rainfall, especially through the growing season. If partial soiling is

[1] Published by permission of the Director of the Nebraska Experiment Station.

[2] Now Professor of Dairying at Storrs, Conn.

[3] Now engaged in farming in western Nebraska.

[4] Now Professor of Dairying at Washington State College.

practiced—that is, part of the year when the cows would ordinarily be on pasture—eastern Nebraska conditions are well adapted, for sufficient rainfall is obtained nearly every summer. Figures obtained from the United States Weather Bureau at Lincoln substantiate this fact. They are as follows: Average rainfall for the last forty years for eastern Nebraska—29 inches; 1914—26.53 inches; 1915—29 inches. The year 1914 and 1915 are mentioned because the data given later in this discussion were compiled during these years.

Besides sufficient rainfall, a productive, well drained soil is essential because the growing of several crops on one piece of land is a severe drain on the available plant food capable of being liberated during a growing season. In this respect also eastern Nebraska is well favored, there being a deep layer of Loess soil over the major portion. With these two conditions, sufficient rainfall and a rich, well drained Loess soil, soiling can be practiced in every county in eastern Nebraska.

In connection with soil and climate, good markets are essential for the disposal of dairy products, especially when soiling is practiced, for this system is intensive and requires the expenditure of considerable money. Therefore, a ready market is necessary. This fact, that ready and near by markets are essential often necessitates the use of high priced land. Since there is a heavy expense to the soiling system, cheap land is not well adapted because on this kind of land grazing is more economical and does not call for the expense of sowing and harvesting fresh forage; besides, a larger area must be made use of, thus we see that the soiling system is a means of saving land, since a large amount of forage can be raised on a piece of land that would be entirely too small were it used for grazing.

In this experiment five plots 40 feet by 321 feet or an acreage of 1.47 acres furnished enough forage for four cows except some field corn and in 1915 one feeding period of thirteen days when alfalfa was used. If pasture had been used the four cows would have required 8 acres.

Not only is there a saving of land, but also the saving of fencing, for under the soiling system no fences are required.

This is a large saving to the stockman as the initial cost of fencing is considerable and the time spent in almost continual repairing amounts to quite an item during the year.

Quite as important as any of the above items is the value of the manure. Land that is cropped as extensively as when soiling is practiced needs a great deal of humus and plant food. By saving and applying the manure, the fertility of the soil is assured and a continuation of the intensive methods necessitated by this form of farming is possible. The dairy cow is fed concentrates, and the manure made in this manner is much more valuable, besides it can be put on the land which needs it most and can be applied when most needed. If litter is added, the humus content of the soil is maintained and in this way its physical condition is such that a luxuriant growth is possible.

In specialized dairy farming the work of growing and harvesting a soiling crop correlates well with the work of the dairy. During the middle of the day when the cows need but little or no attention, the labor can be employed in cutting and hauling the forage to the cows. In this way the men can be steadily employed and the most efficient labor or the greatest returns from labor is made possible. The men employed exclusively in dairy work will usually appreciate this opportunity of getting into the fields for a short period each day.

The soiling system is of special importance in furnishing a succulent and palatable ration during the time when pastures are short, usually during July and August in many sections. Otherwise, the milk flow would decrease and a decided falling off in revenue would be the result, besides the cows would not return to their normal flow when pastures again become good.

The main objection offered to the soiling system is the labor problem. Regularity in cutting the forage must be adhered to whether the weather is good or bad. Since approximately 100 pounds must be supplied to each cow per day, the labor of handling this amount is considerable.

In addition to the harvesting, a succession of crops is absolutely necessary or the plan will fail if soiling is to be depended on alone. Again, during the latter part of July and the first of August it

may be too dry for the crops to grow or for the seed to even germinate. This would be a serious handicap and must be provided for in this case with forage such as alfalfa, clover, or field corn.

Table 1 shows a plan for soiling crops sufficient for a herd of ten cows. The rotation may be worked out from these dates.

TABLE 1

Plan for ten cows

CROP	DATE SOWN	DATE HARVESTED	NUMBER OF ACRES	YIELD PER ACRE	SEED PER ACRE
				tons	
Rye or wheat........	9/15	5/1–5/20	1	5–6	8 pecks
Alfalfa............	9/1	5/20–8/10	½	3–6	18 pounds
Canada peas and oats	4/1	5/20–8/10	½	9	6 pecks each
Canada peas and oats	4/10	6/20–6/30	½	9	6 pecks each
Canada peas and oats	4/20	6/30–7/10	½	9	6 pecks each
Alfalfa (second)......	9/1	7/1–7/20	½	1–3	18 pounds
Early corn..........	5/5	7/10–7/30	½	10	⅕ bushel
Early corn..........	5/15	7/20–8/10	½	10	⅕ bushel
Black cowpeas.......	5/15	8/10–8/20	½	9	4 pecks
Alfalfa (third).......	9/1	8/20–9/1	½	2–4	18 pounds
Late corn..........	5/25	9/1–9/20	½	10	⅕ bushel
Barley and peas.....	8/1	9/20–10/5	½	10	1½ bushels each
Barley and peas......	8/10	10/5–10/20	½	10	1½ bushels each

TABLE 2

Condensed form of the yield in tons of green feed as well as the dry matter contained per acre

	YIELD PER ACRE IN TONS	
	Green	Dry
Rye....................................	6 5	0.9
Wheat..................................	6 5	0.85
Peas and oats...........................	3.5	0.9
Rape...................................	6.3	1.0
Corn...................................	7.0–8.0	1.5–1.7
Cane...................................	10.3	2.9
Alfalfa		
First crop.............................	5.0	1.5
Second crop...........................	3.0	0.9
Third crop............................	4.0	1.2
Pasture................................	2.5	0.5
Silage.................................	8.0	2.4

Alfalfa should stand for five or six years. Vining cowpea should be sown with late corn. Corn or alfalfa may very well be substituted for some of the other less common crops.

A very satisfactory rotation for soiling crops may be worked out for Nebraska conditions using corn and alfalfa as the principal crops, alternating them as much as possible and using just enough of other crops to make connecting links between the cuttings or periods of these two.

OBJECTS

1. To determine for Nebraska conditions the most desirable rotation of soiling crops with respect to yield, date of planting, and date of harvesting, together with an estimate of the cost of growing and harvesting.
2. To determine the value of soiling crops as compared with summer silage in the ration for milk production.
3. To ascertain the comparative economy of butter fat produced by the cows fed on soiling crops and those fed on silage and alfalfa hay.

THE PLAN IN GENERAL

1. Cropping. Five plots of land, 40 by 321 feet in size, were set aside for use in growing soiling crops. In the fall all plots were heavily manured and plowed to a depth of 6 inches, the soil being a rich black loam. This provided for a succession of soiling crops so that abundant green feed might be raised throughout the summer for at least four cows.

In handling these plots exact records were kept regarding preparation of the ground previous to planting, kind and amount of seed sown, method of seeding, rate of seeding, cultivation, date of harvesting, yield per acre, time required to prepare ground for seeding, time required to seed, cultivate and harvest.

2. Crop analyses. These crops were all used for soiling. At the time harvesting was begun on any crop a sample was taken for moisture determination in relation to air dry basis. At the time of completing this harvesting, another sample was taken

for moisture determination to dry air basis. These two samples were then composited on the basis of their fresh weights and a complete analysis made.

3. Feeding. Eight cows were selected for feeding in order to compare soiling crops with silage for milk production.

All of these cows were kept in dry lots. Four of them were fed soiling crops ad libitum from a rack to which they had access day and night except during milking hours. The soiling crop feed was not kept separate for each cow. A supply of the crop was cut fresh each morning at nine o'clock. Refuse was weighed back at frequent intervals so that an exact record of the amount eaten was kept.

These four cows were fed grain (made up of a 4:2:1 mixture of corn, bran, and oil meal (O. P.) in amounts deemed sufficient to keep them in normal production condition, an exact record being kept for each cow. Those four cows received no hay.

The other four cows were fed the same grain mixture, together with alfalfa hay and corn silage. The ratio of 1 pound of grain to 1 pound of hay and 4 pounds of silage was maintained for these cows. This makes a ration very nearly balanced for a cow giving any quantity of milk, provided the total amount fed is regulated intelligently. Exact feed records were kept for each of these four cows.

During the three days in the middle of each crop period a composite sample of the milk was tested for butter fat and the weight of the cows taken. Weighing was done in the morning after feeding but before watering, the cows having been without water all night. This weighing and sampling applied to all eight cows.

4. Basis of comparison. All costs in money values have been eliminated from this study and comparisons made on the basis of total nutrients of the feed or its protein and energy content and on the basis of hours of labor in production. The requirements for butter fat for the soiling group was made upon the total nutrients required and upon labor required for growing the soiling crops including plowing, harrowing, and all cultivation, together with the harvesting—the grain being figured at total nutrient content.

The requirements for butter fat for the silage group was made on total nutrient content of all feeds and labor required for growing silage and putting it in silo.

5. *Determination of butter fat.* The amount of butter fat for each feeding period was obtained in the following manner for each group separately.

The amount of milk given by each cow during the time the composite sample was taken was multiplied by the per cent fat in the composite sample. The amount of the butter fat thus obtained from all four cows divided by the total amount of milk produced during this period gave the average per cent of butter far for the particular feeding period. The amount of milk given each day was multiplied by the average per cent of fat for the period and this constituted the butter fat for each day, the total of which made up the amount of butter fat for the period.

LABOR REQUIREMENTS FOR CROP PRODUCTION[5]

These values are given in the equivalent of man labor in order that the results may be computed more directly.

	Hours man labor
Growing corn for silage	48.30
Filling the silo	18 82
Total	67.12

The average yield of silage per acre being eight tons, gives a labor requirement on the standard per ton of 8.39 hours labor, alfalfa hay requires 15.61 hours labor per ton.

Tables 3 and 4 provide a summary of the feeding and production for the first summer 1913.

[5] Data obtained from Professor Filley of the Rural Economics Department, University of Nebraska.

TABLE 3

Soiling group for four cows

PERIOD	GRAIN FED	HAY FED	SOILING CROPS FED	BUTTER FAT PRODUCED
	pounds	*pounds*	*pounds*	*pounds*
7-day—1. Peas and oats	312.0	291	1168	32.4
20-day—2. Rape	845.0	655	2911	95.8
25-day—3. Corn	942.0	236	7428	100.7
30-day—4. Cane	309.0	0	3000	37.1
30-day—5. Alfalfa	1095.6	0	4800	117.9
Total				383.9

TABLE 4

Silage group for four cows

PERIOD	GRAIN FED	HAY FED	SILAGE FED	BUTTER FAT PRODUCED
	pounds	*pounds*	*pounds*	*pounds*
First	292	288	1178	30.3
Second	812	611	3766	94.3
Third	888	239	4875	88.8
Fourth	258	225	1520	33.5
Total				284.9

TABLE 5

1914 crop data

PLOT NUMBER	CROP	FALL PREPARATION	LABOR	SPRING PREPARATION	LABOR	HOW SOWN	LABOR	TREATMENT AFTER SOWING	LABOR
			hours		*hours*		*hours*		*hours*
1	Fall wheat	Plowed and harrowed	$1\frac{3}{4}$			Press drill	$\frac{1}{2}$		
2	Kherson oats and Canada peas	Plowed	$1\frac{1}{2}$	Disked and harrowed	$\frac{3}{4}$	Broad cast	$\frac{1}{2}$	Twice harrowed for peas and once for oats	$\frac{1}{2}$
3	Fall rye	Plowed and harrowed	$1\frac{3}{4}$			Press drill	$\frac{1}{2}$		
4	Swedish select oats and Canada peas	Plowed	$1\frac{1}{2}$	Disked and harrowed	$\frac{3}{4}$	Broad cast	$\frac{1}{2}$	Twice for peas, once for oats	$\frac{1}{2}$
5	White sweet clover	Plowed	$1\frac{1}{2}$	Disked and harrowed	$\frac{3}{4}$	Wheelbarrow seeder	$\frac{3}{4}$	June 3, clipped weeds 6″ high	$\frac{1}{2}$

PLOT NUMBER	RATE OF SOWING	DATE OF SOWING	HARVEST BEGAN	HARVEST ENDED	YIELD PER ACRE GREEN WEIGHT	REMARKS
					tons	
1	64 pounds per acre	October 18, 1913	May 25, 1914	June 3	13.0	
2	$1\frac{1}{2}$ bushels per acre	April 10	June 4	June 13	11 5	Rain nearly every night. Oats quite wet when weighed
3	102 pounds per acre	October 8, 1913	May 14, 1914	May 24	13.5	
4	$1\frac{1}{2}$ bushels per acre each	April 10	June 14	June 24	13.1	
5	20 pounds seed in fall per acre	April 13	June 25	July 2	10.7	Some weeds in the forage

TABLE 6

Second crop or sowing, for 1914

PLOT NUMBER	CROP	PREPARATION OF LAND	LABOR	HOW SOWN	LABOR	RATE OF SOWING	YIELD PER ACRE GREEN FEED
			hours		*hours*		
1	N ½ oats and peas	Plowed and harrowed	¾	Press drill	¼	1½ bushels per acre each	2.9
	S ½ cowpeas	Plowed and harrowed	¾	Press drill	¼	102 pounds per acre	8.3
2	Hungarian millet	Plowed and harrowed	1½	Press drill	½	68 pounds per acre	10.2
3	N½ cane	Plowed and harrowed	¾	Press drill	¼	102 pounds per acre	19.26
	S ½ soy beans	Plowed and harrowed	¾	Press drill	¼	68 pounds per acre	6.49
4	S ½ white Kaffir	Plowed and harrowed	¾	Press drill	¼	68 pounds per acre	12.2
	N ½ cane	Plowed and harrowed	¾	Press drill	¼	68 pounds per acre	18.2

In 1915 the same number of cows were used as in 1914—namely, two Jerseys, one Holstein, and one Ayrshire. The same plots were used as in 1914 and were also heavily manured and plowed in the fall of 1914. Besides corn, alfalfa was used as a forage in addition to the crops from the five plots and was cut from a field which was rented. Therefore, in estimating the cost of butterfat, only the rent of the alfalfa ground and time in harvesting were taken into consideration.

TABLE 7

1915 crop data

PLOT NUMBER	CROP	FALL PREPARATION	LABOR	SPRING PREPARATION	LABOR	HOW SOWN	LABOR	TREATMENT AFTER SOWING	LABOR
			hours		*hours*		*hours*		*hours*
1 E½	Rye	Disked, plowed and harrowed	4			Press drill	20 minutes each		
1 W½	Wheat								
2	Kherson oats and Canada peas	Plowed	2	Disked and harrowed, rolled	1¼	Press drill	½		
3	Swedish select oats and Canada peas	Plowed	2	Disked and harrowed, rolled	1¼	Press drill	½		
4	Kherson oats and Canada peas	Plowed	2	Disked and harrowed, rolled	1¼	Press drill	½		
5	Swedish select oats and Canada peas	Plowed	2	Disked, harrowed, plowed	1¼	Press drill	½		

PLOT NUMBER	RATE OF SOWING	DATE OF SOWING	HARVEST BEGAN	HARVEST ENDED	YIELD PER ACRE GREEN WEIGHT
					tons
1	102 pounds per acre	October 3, 1914	May 1, 1915	May 12	11.7
	64 pounds per acre	October 3, 1914	May 13, 1915	May 20	10.6
2	1½ bushels each per acre	April 12	June 11	June 18	11.2
3	1½ bushels each per acre	April 12	June 19	June 29	11.7
4	1½ bushels each per acre	May 3	June 30	July 8	8.2
5	1½ bushels each per acre	May 3	July 9	July 17	7.6

TABLE 8

Second crops in 1915

PLOT NUMBER	CROP	PREPARATION OF SOIL	LABOR	HOW SOWN	LABOR	RATE	DATE OF SOWING	HARVEST BEGAN	HARVEST ENDED	YIELD GREEN WEIGHT
			hours		*hours*					*tons*
1	Millet	Plowed, harrowed	$2\frac{1}{3}$	Press drill	$\frac{1}{3}$	68 pounds per acre	June 2	July 18	July 25	8.2
2	Soy beans yellow	Plowed, harrowed	$2\frac{1}{2}$	Press drill	$\frac{1}{3}$	51 pounds per acre	June 26			*
3	Amber cane	Plowed, harrowed, disked	3	Press drill	$\frac{1}{3}$	102 pounds per acre	June 29	September 3	September 27	23.8
4	Millet	Plowed once and harrowed five times	$3\frac{1}{2}$	Press drill	$\frac{1}{3}$	68 pounds per acre	July 4	August 27	September 2	5.8
5	Amber cane	Plowed and harrowed	$2\frac{1}{4}$	Press drill	$\frac{1}{3}$	96.6 pounds per acre	July 19	Cut and put in silo	October 11	12.0
1†	Millet	Plowed, harrowed	$2\frac{1}{2}$	Drill	$\frac{1}{3}$	68 pounds per acre	July 31	September 28	October 7	7.7

* So weedy was mowed and plowed under.

† Third crop.

TABLE 9

Summary of the feed consumed and the production made by the four cows that were on the soiling system from May 15, 1914, to September 15, 1914. Soiling system

PERIOD	GRAIN CONSUMED	SOILING CONSUMED	MILK PRODUCED	FAT		WEIGHT OF COWS	LABOR REQUIRED
	pounds	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*hours*
Rye (May 15–24)	400.0	2,032	1,167.5	5.0	58 34	853.4	10.96
Wheat (May 25–June 3)	403 0	2,965	908.1	4.4	39 98	871.1	13.58
Oats and peas (June 4–13)	429 0	6,453	946 1	4.5	42.57	877.1	14.05
Oats and peas (June 14–24)	441.5	6,121	969.0	4.3	41 67	899 0	17.55
Sweet clover (June 25–July 19)	942 0.	13,746	2,094 0	4.4	93 00	868.0	38.25
Corn (July 20–28)	337 5	3,585	765 0	4 25	32 51	875 5	22.75
Cane (July 29–August 9)	450.0	4,860	1,000 4	4 31	43.12	870 2	12.00
Millet (August 10–20)	412.5	3,093	797 6	4.75	37 89	881.0	14.00
Cane (August 21–31)	412 5	4,610	761.1	5 28	40.19	891.0	13.00
Kaffir (September 1–8)	285.0	2,889	508 8	4 70	23 91	905.0	9.66
Cowpeas (September 9–14)	185 0	2,469	335 7	4 80	16.11	900.0	8.00
Total or average	4,698 0	52,823	10,254.0	4 60	469.79	893.34	173.81

TABLE 10

Average daily consumption of soiling per cow as well as her fat production for the summer 1914

	NUMBER OF DAYS	AVERAGE AMOUNT SOILING PER COW PER DAY	AVERAGE AMOUNT MILK PER COW PER DAY	AVERAGE AMOUNT FAT PER COW PER DAY
		pounds	*pounds*	*pounds*
Rye	10	50 8	29 2	1.46
Wheat	10	74.1	22.7	0.997
Kherson oats and peas	10	161 4	23 6	1.06
Swedish select oats and peas	13	117.7	18 6	0.8
Sweet clover	25	137 4	20 9	0 93
Corn	9	99 6	21.2	0 9
Cane	12	101 2	20.8	0 9
Millet	11	70 0	18.1	0 86
Cane	11	105.0	17 3	0 91
Kaffir corn	8	120 0	21 2	0.9
Cow peas	6	137.0	18.6	0 9

TABLE 11

Summary of the feed consumed and the production made by the four cows on the silage system for succulent feed in 1914.

Silage system

PERIOD	GRAIN CONSUMED	SILAGE CONSUMED	HAY CONSUMED	MILK	FAT		WEIGHT OF COWS	LABOR
	pounds	*pounds*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*hours*
Rye	360.0	1,435.0	320.0	1,105 2	3 8	42 00	1,041 0	10.80
Wheat	360.0	1,435 0	345.0	1,086 1	3 58	38.89	1,057.0	11.00
Oats and peas	334 0	1,312 0	378 0	980.2	3 78	37 05	985.4	10.77
Oats and peas	374 0	1,436 6	342.1	1,019 1	3.9	39 74	987.0	11.73
Sweet clover'	837.5	3,193.0	705 2	2,191.4	3 97	87.03	996.0	24.66
Corn	276 5	1,114 0	236.0	695 2	3 98	27 67	1,001.0	7.714
Cane	366.0	1,464 0	360 0	938.4	3.81	35 75	1,000.0	11.73
Millet	335 5	1,342 0	327.8	873 2	3 9	34 05	1,000 6	10.738
Cane	335.5	1,342 0	335 5	824 5	4.06	33 36	1,005 0	10.802
Kaffir	244 0	976 0	244 0	543 6	4 06	22.06	1,040 0	7.856
Cowpeas	183 0	732.0	183 0	371.7	4.20	15 61	1,041 0	5.982
Total or average	4,015 0	15,781.6	3,716 0	10,628 6	3 9	413 22	1,014 0	123 69

September 1, one cow taken off the experiment and taken to state fair for educational exhibit.

TABLE 12

Summary of 1914 trial

PERIOD	SOILING GROUP			SILAGE GROUP			
	Grain per 100 pounds milk	Soiling per 100 pounds milk	Labor per 100 pounds milk	Grain per 100 pounds milk	Silage per 100 pounds milk	Hay per 100 pounds milk	Labor per 100 pounds milk
	pounds	*pounds*	*hours*	*pounds*	*pounds*	*pounds*	*hours*
Rye (May 15–24)	34 26	174 22	0 94	32 57	129 84	28 95	0.977
Wheat (May 25–June 3)	44 38	326.50	1 38	33 14	132.12	31.76	1.01
Oats and peas (June 4–13)	45 56	682 06	1 48	34 07	133 85	38 56	1.10
Oats and peas (June 14–24)	45 56	631 37	1 81	36.70	140 96	33 57	1.15
Sweet clover (June 25–July 19)	44 98	656 44	1 91	38 22	145 76	32.18	1.12
Corn (July 20–28)	44 12	468 62	2 97	39 77	160 24	33.95	1.11
Cane (July 29–August 9)	45 00	486 00	1 20	39 00	156 01	38 36	1 35
Millet (August 10–20)	51 71	387 78	1 77	38 20	153 68	37.54	1.23
Cane (August 21–31)	54 19	605 70	1 70	40 69	162 76	40.69	1.31
Kaffir corn (September 1–8)	56 01	567 86	1 90	44 88	179 54	44.88	1 44
Cowpeas (September 9–14)	55 10	732 49	2 38	49 23	196 78	42 23	1 55
Average	47 35	519.91	1 77	38 77	153 77	36 60	1 21

Number of days experiment covered 122.

TABLE 13

Average daily consumption of soiling per cow as well as her production of fat for the summer 1915

PERIOD	NUMBER OF DAYS	AVERAGE AMOUNT SOILING PER COW PER DAY	AVERAGE AMOUNT MILK PER COW PER DAY	AVERAGE AMOUNT FAT PER COW PER DAY
		pounds	*pounds*	*pounds*
Rye	12	93	26.6	1.03
Wheat	8	81	34.0	0.94
Alfalfa	13	109	33.8	1.2
Sweet clover	8	129	33 3	1.3
Kherson oats and peas	8	138	32.1	1.16
Swedish select oats and peas	11	128	29.1	1.15
Kherson oats and peas	9	127	28.4	1.1
Swedish select oats and peas	9	110	27.1	1 05
Millet	8	132	25.7	1.11
Corn	13	115	28.4	0.91
Corn	19	107	24 9	0 99
Millet	7	115	22.7	1.0
Cane	25	104	20 8	0.83
Millet	10	77	15.0	0.70

TABLE 14

Summary of the feed and production of four cows that were on the soiling system for succulent feed, 1915. Soiling system

PERIOD	GRAIN CONSUMED	SOILING CONSUMED	MILK PRODUCED	FAT		WEIGHT OF COWS	LABOR REQUIRED
	pounds	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*hours*
Rye (May 1–12)	318 0	3,360	957 6	3 89	37 25	950	14.93
Wheat (May 13–20)	340 0	2,600	1,088 8	4 20	45 73	1,063	12.33
Alfalfa (May 21–June 2)	552 5	5,685	1,757 9	3 76	66 09	1,043	16 25
Sweet clover (June 3–10)	332 0	4,120	1,076 5	4 04	43 49	1,008	14.08
Oats and peas (June 11–18)	288.0	4,430	1.029.2	3 62	37.25	1,024	12.25
Oats and peas (June 19–29)	396 0	2,660	1,281 8	3 97	50 88	1,030	15 00
Oats and peas (June 30–July 8)	333 0	4,585	1,022 9	3.88	39 69	1,027	14.50
Oats and peas (July 9–17)	333 0	3,970	974 9	3 89	37 92	1,027	15.25
Millet (July 18–25)	296 0	4 230	825 3	4 32	35.15	1,024	12.66
Corn (July 26–August 7)	529 5	5,992	1,477 5	3 20	47.28	1,000	34.97
Corn (August 8–26)	836 0	8,128	1,892 6	3.97	75 13	996	59.88
Millet (August 27–September 2)	308.0	3,225	636 6	4 40	28 01	1,024	14.83
Cane (September 3–27)	1,001.0	10,450	2,033.0	4.02	83 74	1,005	50.33
Millet (September 28–October 7)	255.0	3,105	603 2	4 70	28 35	1,081	24.08
Total or average	6,118 0	69,550	16,707 5	3.99	656.45	1021.5	321.34

TABLE 15

Summary of the production and feed for the cows that were on the silage system, 1915. Silage system

PERIOD*	GRAIN CONSUMED	SILAGE CONSUMED	HAY CONSUMED	MILK PRODUCED	FAT		WEIGHT OF COWS	LABOR REQUIRED
	pounds	*pounds*	*pounds*	*pounds*	*per cent*	*pounds*	*pounds*	*hours*
Rye†	426 0	1,624	350	1,289.7	4.45	57.39	1,059	12.29
Wheat	284 0	1,040	231	800 6	4.57	36 59	1,077	8 00
Alfalfa	435 5	1,716	403	1,276 1	4 50	57.42	1,067	13.34
Sweet clover	260.0	1,016	234	777 2	4 20	32.72	1,085	7.94
Oats and peas	261 0	1,000	234	753 5	4 27	32.17	1,071	7.87
Oats and peas	352 0	1,390	317	947 2	4.45	42 15	1,064	10.84
Oats and peas	288 0	1,152	282	716.6	4 45	31 88	1,054	9 11
Oats and peas	245 0	946	222	623 4	3.96	24 69	1,041	7 81
Millet	247 5	889	180	550 7	4 60	25 33	1,041	6 99
Corn	401 0	1,536	310	883 4	4 13	30 48	1,050	11.87
Corn	594 0	2,024	522	1,089 6	4 70	51.21	1,063	17 02
Millet	161 0	644	161	345 5	4 60	15 89	972	5.61
Cane	575.0	1,901	483	1,145 5	4 56	52 23	978	17.72
Millet	230 0	893	227	414 9	5.10	21 16	992	7.88
Total or average	4,760.0	16,681	4,150	11,613 9	4 46	517 23	1,052	254 95

* Three cows only on this feeding period.

† Under "period" is given the soiling crops period merely to designate the corresponding conditions of the silage group and does not mean that these animals received the feed listed under "period."

TABLE 16

Summary of 1915 trials

PERIOD	SOILING GROUP			SILAGE GROUP			
	Grain per 100 pounds milk	Soiling per 100 pounds milk	Labor per 100 pounds milk	Grain per 100 pounds milk	Silage per 100 pounds milk	Hay per 100 pounds milk	Labor per 100 pounds milk
	pounds	*pounds*	*hours*	*pounds*	*pounds*	*pounds*	*hours*
Rye (May 1–12)	33 22	350 87	1 56	33 02	133 64	27.13	0.95
Wheat (May 13–20)	31.23	238 86	1 13	35 50	130 00	28 87	1 00
Alfalfa (May 21–June 2)	31 42	323 39	0 92	34 13	134 48	31 58	1 04
Sweet clover (June 3–10)	30 84	383 64	1 30	33 46	130 76	30.11	1 02
Oats and peas (June 11–18)	27 98	430 43	1.19	34 79	132.73	31.18	1 04
Oats and peas (June 19–29)	30 88	441 56	1 17	37 18	146 75	33 46	1 14
Oats and peas (June 30–July 8)	32.55	448 23	1 41	40 18	160 75	39 35	1 27
Oats and peas (July 9–17)	35 15	407 11	1 56	39 30	157 74	35 61	1.25
Millet (July 18–25)	35 86	512 72	1 53	45 94	161.44	32.68	1 27
Corn (July 26–August 7)	35 85	405 68	2.36	45 39	173 87	35.08	1 34
Corn (August 8–26)	44 16	429 31	3.16	54 51	184 49	47 91	1.56
Millet (August 27–September 2)	48 42	507 07	2 32	46 59	186 49	46 59	1.62
Cane (September 3–27)	48 05	501 68	2 41	50 19	165 95	42 16	1.54
Millet (September 28–October 7)	42 28	514 92	3 99	55 43	215 20	54.71	1.89
Average	36 27	421 1	1 857	41 83	157.70	36 88	1.28

Number of days experiment covered 160. Since the corn fed was cut from field no records were kept to show the labor in production. This was determined from the Rural Economics Department surveys, 48.3 man and horse hours labor per acre to time of harvesting.

The alfalfa feed as soiling was taken from a field and no labor charge was used for the preparation of ground.

The sweet clover plot was used two years with one seeding so the labor of preparation and seeding was divided for two years.

TABLE 17

Average of two years 1914–1915

PERIOD	SOILING GROUP			SILAGE GROUP			
	Grain per 100 pounds milk	Soiling per 100 pounds milk	Labor per 100 pounds milk	Grain per 100 pounds milk	Silage per 100 pounds milk	Hay per 100 pounds milk	Labor per 100 pounds milk
	pounds	*pounds*	*hours*	*pounds*	*pounds*	*pounds*	*hours*
Rye	33.745	262.545	1 25	32 79	131.74	28.04	0 963
Wheat	37 800	283.180	1 25	34 32	131.065	30.31	1.000
Oats and peas	36 280	506.79	1.43	37.03	144.460	35.28	1.158
Sweet clover	31.915	520.04	1 60	35 84	138 26	31.145	1.070
Corn	41.370	434 530	2 83	46 556	172.776	38.980	1.330
Cane	49 080	531.126	1.77	43 290	161.570	40.400	1.400
Millet	44.567	480 625	2 402	46 540	179.170	42.880	1.50
Kaffir	56 010	567.860	1.900	44 880	179 540	44 880	1 44
Cowpeas	55.100	732 490	2 380	49 230	196 780	42 230	1 55
Alfalfa	31.420	323 390	0.92	34 130	134.380	31.580	1.04
Average	41.728	464 257	1.77	40 460	156 975	36 573	1 245

TABLE 18

Showing chemical analysis of all feeds that were used in the soiling crops experiment, per 100 pounds of feed

	DRY MATTER	CRUDE PROTEIN	TRUE PROTEIN	ENERGY
Silage	26 3	1.1	0.6	15 90
Sweet clover	34 4	3.3	2 2	17.30
Canada peas	16 6	2.9	2.1	9 78
Corn	23.1	1.0	0.8	14 60
Rye	21 3	2.1	1 4	15 99
Wheat	27 4	2.8	1.9	18 75
Cane	24 9	0.7	0 4	15 37
Oats	26 1	2.3	2.0	14 06
Alfalfa hay	91 4	10.6	7.1	24 23
Millet	27 6	1 9	1.1	17.24
Oats and peas	21.3	2 6	2 05	11.92
Grain mixture	89 8	12.17	11.15	78 79
Kaffir corn*	14 9	1 1	0.8	13 64
Cowpeas	16 3	2 3	1.7	10 42
Alfalfa (green)	25 9	3.3	1 8	11 50

* No analysis was given for kaffir so dent fodder in tassel was used as a substitute.

TABLE 19

Digestible nutrients required to produce 100 pounds of milk, 1914

PERIOD	SOILING SYSTEM				SILAGE SYSTEM			
	Dry matter	Crude protein	True protein	Net energy	Dry matter	Crude protein	True protein	Net energy
Rye	67 85	7 937	6.995	54 86	89 943	8 468	6.480	53 317
Wheat	129 314	14 55	11.170	95 92	93 529	8 862	6.757	54.812
Oats and peas	186 178	23 291	19 22	117 06	101 016	9 714	7 354	57.441
Oats and peas	175.378	21 97	18.18	111 02	1·0 594	9 584	7 228	59 445
Sweet clover	266 19	27.05	20.16	149 50	100 52	9 675	7.438	61.07
Corn	147 86	10.068	8.69	103.18	108 875	9 211	7.698	65.024
Cane	161 424	8 892	6.984	110 158	111 131	10 540	8.027	64.819
Millet	153.43	13.673	10 054	107 578	109 037	10 328	7.864	63.506
Cane	199.481	10 85	8.49	145 79	116 537	11.067	8 422	67.725
Kaffir corn	134.898	13 078	10 815	121 582	128 53	12 206	9 289	74.771
Cowpeas	168.876	23 569	18 623	119 744	134 538	12.645	9.691	80.287
Average	162.846	15.902	12.67	112 399	108 564	10 20	7.840	63.837

TABLE 20

Digestible nutrients required to produce 100 pounds of milk, 1915

PERIOD	SOILING SYSTEM				SILAGE SYSTEM			
	Dry matter	Crude protein	True protein	Net energy	Dry matter	Crude protein	True protein	Net energy
Rye	104 436	11.42	8 632	81 321	89 583	8.372	6 425	53 826
Wheat	91.947	10 496	8 034	69 264	92 456	8 821	6.806	55 630
Alfalfa	111 975	14 505	9 340	61.949	94 885	8 989	6 870	55.921
Sweet clover	159 652	16.420	11.893	90 663	91 941	8 710	6 668	54.433
Oats and peas	116 800	14 603	10 836	73 265	94 639	9 008	6 905	56.058
Oats and peas	121 769	15 246	12.508	76.870	102.551	9 694	7 419	60.719
Oats and peas	124.695	15.624	12 823	78 984	114 310	10 839	8 257	66.734
Oats and peas	118 276	14 872	12 281	76 142	107.735	10 236	7 839	63 705
Millet	173.707	14.115	9.655	116 441	113 561	10.843	8 433	69.770
Corn	125.909	8.430	7 260	87 481	118 558	11 166	8 616	71 896
Corn	138 823	9.680	8.379	97 475	141 182	13.754	10.611	83 834
Millet	183.440	15 541	10 901	125 375	133 443	12 671	9.643	77.613
Cane	167 971	9 373	7 387	114.523	127 325	12 414	9 609	76.129
Millet	180 079	14 941	10 398	121 878	156.377	14 928	11.383	91.135
Average	137.105	13.233	10 032	90 830	112 746	10.745	8.248	66 957

TABLE 21

Summary for two years showing the summary of each system of summer feeding for dairy cows

	1914		1915		Average	
	Soiling	Silage	Soiling	Silage	Soiling	Silage
Number of days	122.0	122.0	160.0	160.0	141.0	141.0
Pounds of soiling consumed	52,823.0		69,550.0		61,186.5	
Grain consumed	4,698.0	4,015.0	6,118.0	4,512.6	5,408.0	4,263.8
Silage consumed		15,781.0		16,681.0		16,231.0
Hay consumed		3,716.0		4,150.0		3,933.0
Pounds of milk produced	10,254.0	10,628 0	16,707.5	11,613.9	13,480.75	11,120.95
Average per cent of fat	4.6	3.9	3.99	4.46	4.29	4.18
Pounds of fat	469.29	413 22	656.45	517.23	562.88	465.22
Hours of man and horse labor	173.81	123.69	321.34	254.95	247.57	189.32
Grain required per 100 pounds milk	47.35	38.77	36.27	41.83	41.81	40.30
Soiling required per 100 pounds milk	519.91		421 10		470 50	
Silage required per 100 pounds milk		153.77		157.70		155.73
Hay required per 100 pounds milk		36.60		36.88		36.74
Labor required per 100 pounds milk	1.77	1.21	1.857	1.28	1.813	1.245
Dry matter required per 100 pounds milk	162.846	108.654	137.105	112.746	149.975	110.555
Crude protein required per 100 pounds milk	15.902	10.20	13.233	10.745	14.567	10.472
True protein required per 100 pounds milk	12.67	7.840	10 032	8.248	11.35	8.044
Net energy required per 100 pounds milk	112 399	63.837	90 830	66.957	101.614	65.397
Weight of cows at beginning	853.4	1,041.0	950.0	1,059.0	901.2	1,050.0
Weight of cows at end	900.0	1,041.0	1,081.0	992.0	990.5	1,016.5
Acres of ground required	2.14	1 60	2.75	1.731	2 445	1.665

CAUSE FOR CERTAIN VARIATIONS

The butter fat varies somewhat but there is a gradual rise in feed required for production due to the advance in lactation period. Also, adverse weather conditions cause an increase in the expense. For instance, in the sweet clover period for 1914 there was considerable rainy weather and strong winds. This caused the forage to become badly lodged. This necessitated the expenditure of considerable time in harvesting the crop. In the case of feeding corn much time was expended in cutting up the corn into short lengths and hauling away the refuse stalks.

It will be noticed as well that some of the crops as corn and sweet clover were the only crops obtained from the same piece of land, while other plots of land raised two and some three different crops. This fact was responsible for a less expense because the rent was the same whether one or three crops were raised on the plot.

The reason for the less expense in producing butter fat on the sweet clover for 1914, than for 1915 is due to the fact that the expense of preparation of the soil, sowing the seed, and harvesting are charged to the 1914 account while the harvesting only is charged to the 1915 account.

It will be seen by the above data that in eastern Nebraska soiling can be practiced with profit. The milk flow was kept up, the climate was such that a rotation of palatable forage was possible, the cows showed by their increase in weight that the ration was healthful and nutritious and that there was a great saving in the acreage of land over the pasture system. The main objection, that of labor, remains the same as everywhere but this can be overcome.

This conclusion is not necessarily a plea for the soiling system in eastern Nebraska and the time is not yet at hand when soiling should be extensively practiced, yet it has been demonstrated that soiling is possible, that a rotation of crops can be planned that will furnish forage from the time of early summer until silage is available in the fall or through the summer when pastures are short which condition means a decrease in milk flow.

The special soiling crop plots comprised 1.47 acres and the yield was 26.71 tons of green feed. The sweet clover was grown on special plot which joined the other plots and required .52 acres. The yield of green feed was 6.957 tons. Because of lack of feed the corn used was cut from another field; 0.15 acres yielded 1.63 tons. With these additions the total amount of ground used in the soiling system was 2.14 acres and yielded 35.29 tons of green feed. Not all this feed, however, was used by the cows in the experiment but it should be charged to them because the project was planned for them and on a farm where there were no other animals available, this surplus would have been wasted. The total amount of soiling crop used was 52,823 pounds or 26.41 tons; this being 74 per cent of all feed produced.

The fact that some of the feed was not used for the soiling group together with the fact that certain crops did not give as great yield as was anticipated would tend to show a greater acreage necessary for soiling crops than is ordinarily assumed.

1914 SILAGE SYSTEM[6]

The amount of silage consumed was 7.89 tons.

The amount of alfalfa hay consumed was 3.86 tons.

The average production for Nebraska is 8 tons of silage per acre. Using these figures it required 0.98 acre to produce the silage. The average production for alfalfa is 3 tons per acre would require 0.62 acre; for both silage and alfalfa the total requirement was 1.60 acres.

1914 AND 1915 SOILING SYSTEM

The same plots were used in 1915 as in 1914 comprising 1.47 acres and yielded 31.10 tons of green feed.

The corn used was taken from a plot covering 0.56 acre and yielded 10.36 tons.

The sweet clover was grown on a plot of 0.52 acre and yielded 5.58 tons.

[6] Averages are taken here because the silage and alfalfa hay were weighed up from the general herd supply rather than being produced on separate measured plots.

The alfalfa was taken from plot of 0.2 acres and yielded 2.84 tons.

The total amount of ground used was 2.75 acres and yielded 49.88 tons of green feed. The actual amount fed was 34.750 tons or 69.6 per cent of the amount produced. There was 30.4 per cent wasted, lost or used for some other purpose.

1915 SILAGE SYSTEM

The amount of silage consumed was 8.34 tons.

The amount of hay consumed was 2.075 tons.

It required 1.04 acres for the silage.

It required *0.691 acres for the alfalfa hay.*

The total was 1.731 acres for the silage crops.

The total amount of feed required was greater for the soiling system. One year, the soiling system used more grain per 100 pounds of milk and the other year the opposite condition was true. The average for the two years the soiling crop required a greater amount of grain per 100 pounds of milk. Also under the soiling system there was a greater amount of roughage used.

The soiling crop was of course high in water content and a greater amount of dry matter was also required. As an average for the two years the soiling system produced more milk and a greater amount of fat, which is proportionate to the increased consumption of feed. However, the greater amount of nutrients required under soiling system shows that the soiling was less efficient and more expensive for milk production. As is expected the soiling system required slightly more labor than the silage system and the soiling system, contrary to general belief required a greater acreage.

SUMMARY

1. Soiling crops are successful where rainfall is dependable and palatable feed furnished for dairy cows. The system is well adapted to eastern Nebraska conditions.

2. Soiling crops correlate well with specialized dairying in distribution of labor throughout the day.

3. Succession of crop is necessary for successful soiling system.

4. Fall seeding is necessary in providing soiling crops for the early summer.

5. Cows will maintain a more constant yield throughout the summer on a good ration of soiling crops than on most any other feeds.

6. Cane shows a greater yield per acre than any other of the crops that were used in the soiling system.

7. In 1914, the total hours of labor for the soiling crops was 173.81 as compared with 123.69 hours for silage feeding. Hours of labor per 100 pounds of milk soiling crops 1.77. Silage 1.21. This does not include milking and care of the cow.

8. In 1915, the labor for feed in producing 100 pounds of milk was 1.857 hours for soiling crops and 1.28 hours for silage.

9. The labor requirement for alfalfa as a soiling crop was lower than any other, while the labor for millet and for cowpeas was greatest.

10. The use of either silage or soiling crops for summer feeding of dairy cows decreases the necessity for a heavy grain ration.

ADVANTAGES OF SOILING

1. Permits production of milk free from flavors due to pasture weeds.

2. Furnishes a succulent ration and maintains a continuous milk supply when pastures may be seriously affected by drouth.

DISADVANTAGES OF SOILING

1. It requires a man and team daily to cut and haul a supply of forage to the feeding yards, interfering with the regular farm work.

2. Even with careful planning the season may be such as to hinder the development of the crop with subsequent shortage of feed.

3. Soiling crops must be gathered in all kinds of weather. In rainy weather the feed may be so wet and "washy" as to cause digestive disorders.

4. Another disadvantage of the soiling crop system is that there is always more or less waste. The product is good only for a short time as green feed and if not used then it must be used for some other purpose or it becomes a loss to be charged to the system of management.

ADVANTAGES OF SUMMER SILAGE

1. Feed is always on hand without any additional work.
2. Will keep for an indefinite length of time if properly prepared.
3. Relished just as much as is a soiling crop.
4. Independent of climatic conditions as supply is from previous summer.
5. Silage always under cover, hence does not require harvesting in all kinds of weather.
6. Cheaper succulent feed than soiling crop.

FIG. 1. KHERSON OATS AND CANADA PEAS. EARLY PLANTING

FIG. 2. KHERSON OATS AND CANADA PEAS. LATE PLANTING

Fig. 3. Sweet Clover May be Used as Soiling Crop

Fig. 4. Alfalfa Made Good Soiling Crop. Second Cutting

FIG. 5. MILLET SOWN FOR SOILING CROP

FIG. 6. SWEDISH SELECT OATS AND CANADA PEAS. EARLY PLANTING, 1915

FIG. 7. YOU NEED NOT RAISE CORN OF A SMALL VARIETY FOR SOILING CROPS

FIG. 8. CORN USED FOR SOILING CROPS SHOULD BE PLANTED THICK

ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

October 11, 1920[1]

Meeting was called to order by President Mortensen, who called for a report from the secretary. The secretary's report which follows shows the financial condition of the Association. It was recommended by the secretary that we provide some means for increasing the revenue to the Association.

Following the secretary's report President Mortensen gave the annual address. Among his suggestions were recommendations for a committee on membership, also a committee on program for the annual meeting. President Mortensen also strongly advised that we hold our annual meeting in sections as follows: (1) Relation to breed associations, (2) dairy production, (3) dairy manufacturing, (4) extension workers. During the course of his address our president strongly emphasized the need for workers in both teaching and investigation.

BUSINESS SESSION

Moved by Harding, seconded by Davis that a committee on program and a committee on membership be selected. Carried.

At this point Professor Eckles was called upon to give some interpretations of the membership clause in the new constitution. Dr. Harding also spoke on the question of membership, urging a broader interpretation of the membership clause.

This matter was referred to the committee on constitution for a recommendation to be presented at the next annual meeting.

Professor Mortensen announced that during the afternoon the meeting would be held in sections as previously outlined.

Previous to adjournment Professor Mortensen introduced Mr. A. P. Hansen, dairy expert from Denmark, who spoke briefly of his work to the Association.

Adjourned.

[1] Credit is due President Mortensen and Secretary N. W. Hepburn for preparation of this report.

October 11, Afternoon Sessions

DAIRY PRODUCTS SECTION

At the opening of this session Dean Van Norman was introduced. The Dean spoke very enthusiastically concerning the desirability of holding a world's dairy congress.

Following Dean Van Norman's talk, it was moved, seconded, and carried that the matter of a dairy congress be made a special order of business at the evening banquet.

Moved, seconded, and carried that a nominating committee be appointed to select the officers for the manufacturing section.

Committee selected was Harding, Guthrie, Bouska.

At this point committee reports were called for. Dr. Harding made a report on milk quality which follows:

Report of the Committee on Milk Quality

At its last annual meeting this Association adopted a resolution stating that it "approved of the standardization of milk under proper supervision" and directing its committee on milk quality to get in touch with others interested in this subject.

In accord with these instructions the subject of standardization of milk was presented to the annual meeting of the International Milk Dealers Association. Many of the members expressed themselves as very favorable to the proposition. However, some members opposed the idea as introducing further complications into an already badly mixed situation. Because of this difference of opinion no official action was taken or committee appointed by this Association. From what could be learned there seemed to be little opposition to the principle involved; however, there was the feeling that the success of such an innovation would depend largely upon how it was administered. Accordingly they hesitated to approve standardization, preferrring to leave the initiative to their health officials.

The subject was also brought to the attention of the National Milk Producers Federation. They have a standing committee on milk quality and at their annual meeting this committee presented a report of substantially the same tenor as the resolution adopted by our Association. However, in the discussion of this report from the floor it developed that the question of standardization was under discussion

at some of the larger cities and the sentiment of the producers in these regions was divided in the matter. On this account the report was referred back to the committee with instructions to study the question and report at the coming annual meeting. Conference with the leading members of the Federation developed the fact that the leaders were not opposed to standardization and a number of them were strongly in favor of it. However, as their annual meeting is that of a delegate body they hesitated to commit the organization to any policy regarding a question which had not been presented to their constituency.

As an indication of the present interest in this subject the definition of milk as contained in an ordinance adopted about a year since at St. Paul, Minnesota, is interesting. That portion of the definition relating to standardization follows:

Legal milk.—All milk sold in the City of Saint Paul shall be the fresh, clean normal lacteal product from healthy cows, outside the period of fifteen days before and five days after calving, or until free from colostrum. It shall be free from visible dirt, pathogenic bacteria, objectionable odor, flavor or color, and shall contain not more than two-tenths per cent (0.2 per cent) acidity. It shall contain not less natural butterfat, not less milk solids, not fat, nor less total milk solids than required by the state law, and not more water than permitted by the state law. Its specific gravity shall be not less than 1030 at 60° Fahrenheit, it shall contain no added substance except normal equally pure milk or cream. The mixing or blending of different lots of milk, cream or skim milk which conforms to the standards established by this ordinance for the purpose of standardizing the butterfat content is not prohibited.

It should be noted that this ordinance does not provide for a standardized product having a percentage of fat or solids not fat lower than the state minimum legal limits. This may have been in deference to the state law which would have applied regardless of the city ordinance. It should also be noted that it provides only for the mixing or blending of milk, cream and skim milk. It is of interest that since the passage of this ordinance a local shortage of whole milk led to the manufacture of milk from milk powder, butter and water. A brisk controversy arose as to the permissibility of this action.

While apparently everyone is prepared to subscribe to the proposition that milk should be standardized provided it is so labeled as to inform the consumer of its real food value, skepticism regarding the latter point leads to the following questions:

1. Shall there be a minimum limit below which standardization shall not be allowed?

Those who would answer this in the affirmative seem inclined to fix this minimum composition either at the legal minimum limit or at the estimated average composition. For example, the St. Paul ordinance already quoted placed the limit at the minimum legal limit, and your committee understands that this is the ruling in the State of Indiana. On the other hand in discussions which have occurred in connection with the milk supply of New York State and the City of Milwaukee, 3.5 per cent of fat has been seriously considered as the lower limit of composition for standardized milk.

2. Shall standardized milk be sold under a special label and if so what kind of a label?

If standardized milk is to be treated as a product distinct from milk the food laws require that it carry a distinctive name. According to the present construction placed upon the food laws by a number of food officials "remade milk," "reconstructed milk" and "standardized milk" are not distinctive names for a product which is not milk.

On the other hand it may be contended that when standardized milk contains no substance foreign to milk it is really milk and its present conflict with some of the legal definitions of milk arise from a lack of logic in these legal definitions resulting from framing the laws to accomplish certain purposes. The sharpest difference of opinion arises over the use of milk powder and butter in reconstructing milk. If they are to be considered merely as milk solids, which have been put into a more convenient form for transportation or storage the product of their recombination may be considered as milk. However, if the product of recombining milk powder or condensed milk, butter and water is to be recognized as milk the necessity of some further designation than merely a statement of fat in order to make evident its food value is plain. It will be held by many that this same index of food value is desirable with all milk and if all milk were required to carry an index of food value no special enactment would be needed for reconstituted milk.

3. Assuming that some index of food value should be carried by milk, what index or indices is necessary in order to protect all parties concerned?

There seems to be a consensus of opinion that a statement of fat content is desirable. Where only cream and skim milk are employed in standardizing some feel that the fat content is a sufficient guarantee of food value. On the other hand wherever water is employed in the standardization there is a general feeling that a statement of solids not fat is necessary as an evidence of food value. Should we treat all

milk alike and require a statement of fat and solids not fat regarding all milk?

There seems to be little agreement upon these three points among the various classes interested in the question of milk standardization and your committee respectfully asks your careful consideration of them, with the prospect later of a questionnaire as a medium of expressing your views.

W. A. Stocking, Jr.
R. S. Breed,
E. G. Hastings,
F. Rasmussen,
H. A. Harding,
Chairman.

The following committee on organization was appointed and asked to report next year: Hunziker, Frandsen, Breed, and Gamble.

A brief report on legal standard for butter was made after which the following motion was offered by Bouska and seconded by Harding.

The motion was carried.

Resolved that the chairman of the committee on butter standards keep informed on national hearings regarding butter fat standards and that he submit to the officials conducting such hearings any information or resolutions which have been adopted on butter standard by the American Dairy Science Association. That said chairman be authorized to sign such communications and that said chairman submit these communications to such state bodies or associations as may be required to secure proper consideration of this matter.

Dr. Breed gave the report on bacteriological methods foi market milk.

The report as given below was ordered filed.

Report of Committee on Bacteriological Methods for Market Milk

There are two matters brought to your attention in the following report:

1. A discussion of the standard methods for the sanitary analysis of milk recently adopted by the American Public Health Association at their meeting in San Francisco.

2. A discussion of the need of state legislation for the control of bacterial analyses of milk where these are used as a basis for payment to dairymen.

Standard methods for the sanitary analysis of milk. Your committee on bacteriological methods has again been asked to coöperate with the American Public Health Association committee in the preparation of a complete revision of the Standard Methods Report. This was done gladly and it is a pleasure to report that the criticisms and informations furnished by the various members of the committee have proved of very material help to the American Public Health Association committee.

A summary of the most important changes from the 1916 report follows. There are no provisions in the report that will cause a radical change in the methods now in use, although there are many things in it which look toward greatly improved conditions.

1. The newer methods for determining the reaction of agar media are included.

2. Emphasis is placed upon the necessity for a sinple and inexpensive technique for agar plating for general routine purposes.

3. However to safeguard the use of these routine methods where punitive actions are to be taken by control officials, the necessity for securing a series of samples is emphasized, and at the same time it is recommended that wherever actions are likely to be questioned in court that they be based upon analyses made with greater care than that used for ordinary routine work. These are spoken of as verification methods.

4. Because of the present extensive use of the Breed microscopic technique the report accepts this as a standard technique of equal standing with the agar plate count when used for judging the quality of unpasteurized milk.

5. Because of the promise of usefulness in the Frost microscopic agar plating technique as a means of getting quick results on all types of milk, this technique is given with the recommendation that it be given a real tryout by the control laboratories of the country.

6. As the use of these different methods of counting the bacteria of groups of bacteria in milk raises the question of the relation between the counts obtained, it is recommended that the present practice of speaking of agar plate counts as showing the "number of bacteria per cubic centimeter" be discontinued and that the agar plate counts obtained by the routine standard method be referred to as "official plate counts." The ratio between the microscopic count showing the true

number of individual bacteria and the official plate count is tentatively placed at 5 to 1.

7. It will be noted from the title of the report that its scope has been broadened to lower the standardization of the methods officially recognized as useful in the determination of the sanitary quality of milk.

8. As bacterial counts merely give us an approximate knowledge of the amount of bacterial life present, other tests useful in determining the sanitary quality of milk are included. These are primarily the sediment test for visible dirt, and the microscopic examination of milk or of milk sediments for the presence of long chain streptococci. Mention is also made of the possibilities for usefulness of other biochemical or bacteriological tests, and the hope is expressed that investigators and control officials will continue experimental work along these lines.

9. In order to satisfy the demand on the one hand that the report be merely a short and technical statement of required procedures, and an equally insistent demand on the other hand that specific descriptions of procedures be given in order that those unfamiliar with standard procedures might have directions at hands, the committee has prepared a descriptive report with a summary of the required procedures at the end of the report. The American Public Health Association committee feels that this has resulted in placing the cart before the horse: but owing to the press of time it was impossible to recast the whole report so as to place the required procedures at the beginning of the report.

State legislation for the control of bacterial analyses of milk where these are used as a basis for payment to farmers. The recent rapid development of the practice for paying for milk on the basis of the number of bacteria present, and the certainty that the future will see a development of this practice has brought out the necessity for a state supervision of the analytical methods similar to that now exercised in many states over the butterfat test. With minor differences, the conditions are almost identical with those surrounding the use of the Babcock-test. These are already thoroughly familiar to the members of this Association.

It appears that this new legislation should take a very similar form to that already in force regarding the Babcock test, namely, (a) the enforcement of the law should be in the hands of the same bureaus that enforce the butter fat law, (b) analysts doing the work should be compelled to show credentials proving their competence for the work, (c) they should be placed under a license system with the power to revoke

the license placed in the hands of the State, (d) the graduated glassware used should be tested under State supervision, (e) the methods of taking and handling samples should be placed under control and provision should be made for the analysis of the milk by impartial analysts wherever a dispute arises, (f) the law should compel the preservation of records or of microscopic preparations so far as this is feasible or desirable.

It is not necessary to recite the particular conditions that make such legislation desirable. Every bacteriologist knows the possibilities for unfair practices in connection with bacterial counts, and will recognize the need for state control. We therefore request the Association to formulate and pass resolutions urging the necessity for this legislation.

R. S. Breed,
L. A. Rogers,
E. G. Hastings,
B. W. Hammer,
J. D. Brew,
Committee.

It was moved, seconded, and carried that a committee be appointed on the matter of a national dairy congress.

The following committee was appointed: Rawl, Eckles, Breed, Hunziker and Gray.

Committee report on official methods for testing milk, and cream for butterfat. Professor Hunziker gave the report which follows:

Report of Committee on Official Methods for Testing Milk and Cream for Butterfat

Your committee begs to submit the following brief report:

The specifications for standard pipettes adopted at our annual meeting in 1916 read as follows:

Pipette, capacity, 17.6 cc. Total length of pipette not more than 330 mm. (13¼ inches). Outside diameter of suction tube 6 to 8 mm. Length of suction tube 130 mm. Outside diameter of delivery tube 4.5 to 5.5 mm. Length of delivery tube 100 to 120 mm. Distance of graduation mark above bulb 15 to 45 mm. Nozzle straight. To deliver its contents when filled to the mark with water at 20°C., in five to eight seconds. The maximum error shall not exceed 0.05 cc.

The clause "*to deliver its contents when filled to the mark with water at 20°C., in five to eight seconds*" leaves in doubt as to whether the pipette is intended to contain and hold 17.6 cc. of water, or to deliver 17.6 cc. of water when the last drop is blown out. This uncertainty has caused a great deal of confusion and controversy in the construction and calibration of pipettes between officials in charge of the enforcement of standard glassware laws in the various states and glassware manufacturers, and in some cases entire shipments of pipettes have been condemned and returned to the manufacturers by state officials because the pipettes did not conform to their interpretation of the law.

It is obvious that the pipette cannot deliver its contents quantitatively because part of the contents will cling to the walls even though the last drop is blown out. The pipette will *deliver* less than it *holds*.

Your committee has subjected this matter to careful study, and in conference with the United States Bureau of Standards, has concluded that the original intention was that the pipette should *hold* 17.6 cc. and not deliver that amount. We therefore beg to recommend to change the wording of the original specification as follows:

Pipette, capacity 17.6 cc. *of water at 20°C*. The total of pipette not more than 330 mm. (13¼ inches). Outside diameter of suction tube 6 to 8 mm. Length of suction tube 130 mm. Outside diameter of delivery tube 4.5 to 5.5 mm. Length of delivery tube 100 to 120 mm. Distance of graduation mark above bulb 15 to 45 mm. Nozzle straight. *To discharge when filled with water in five to eight seconds.* The maximum error shall not exceed 0.05 cc. *In the operation of the test the last drop of milk should be blown out of the pipette into the test bottle.*

Your committee desires to further emphasize that the length and diameter of the discharge and of the standard pipette are of such proportions that the pipette readily slips into the neck of the standard test bottle. This makes it possible when transferring the milk from the pipette to the test bottle, to drop the discharge stem of the pipette into the neck of the test bottle until the bulb of the pipette rests on the flange of the bottle neck. This greatly enhances the speed of the operation and it avoids all danger of spilling.

HUNZIKER.

It is recommended that instructors in milk testing adopt this method of discharging the pipette into the test bottle in preference to the method of holding the pipette in a slanting position and resting the tip of the pipette against the mouth of the neck of the test bottle, which

latter method is awkward, slow of operation and not suitable for commercial use.

Respectfully submitted,

By the Committee,

L. A. Rogers,
H. C. Troy,
Fred Rasmussen,
F. W. Bonuska,
O. F. Hunziker,
Chairman.

Moved by Gamble that the report be accepted. Carried.

Moved by Frandsen that chairman of the committee on glassware be empowered to get in touch with legislative bodies to give our report the proper publicity. Carried.

At this time Professor Mortensen introduced Dr. Swaiving, Chief of the Dairy division, Department of Agriculture, Holland, and Professor Van Dar Berg, College of Agriculture, Holland. Each of these gentlemen made appropriate talks to the Manufacture Division of the Dairy Science Association.

Report by Frandsen on score card for dairy products.

Score card for milk

	points
Bacteria	35
Flavor and odor	25
Visible dirt	10
Fat	10
Solid, not fat	10
Acidity	5
Bottle and cap	5
	100

The committee does not feel warranted at this time in recommending score cards for ice cream, milk powder or condensed milk, but urges that the committee be continued and additional men be added to the committee and that during the coming year an especial study be made relative to score cards of these products.

Moved that the score card as read for milk be used for one year in our contests in judging milk. Carried.

Professor Frandsen reported further that Dr. Harding had submitted a number of suggestions which in substance would call for very radical change in our present milk score card.

Regarding these suggestions, Professor Frandsen said the committee has as yet taken no action, but he desired that Dr. Harding's recommendations should be published so that all members of the association would be familiar with them and ready to discuss and take action regarding same next year.

Suggestions Regarding the Score Card for Milk

The primary object of the milk score card is to point out the real quality of the milk. The present two score cards for milk differ in their allotment for flavor and odor, fat, and solids not fat. Both allotments are given below and alongside is shown these present cards *rearranged* according to the definition of milk quality which has been adopted by this Association.

Present score cards for milk

		Perfect
Bacteria	35	35
Flavor and odor	25	15
Visible dirt	10	10
Fat	10	15
Solids not fat	10	15
Acidity	5	5
Bottle and cap	5	5
	100	100

Present score cards rearranged

		Perfect
Food value		
Fat	10	15
Solids not fat	10	15
Healthfulness, T.B. test, or Pasteurization	0	0
Cleanliness, visible dirt	10	10
Bottle and cap	5	5
Keeping quality, bacteria	35	35
Flavor and odor	25	15
Acidity	5	5
	100	100

Sanitation bulks large in the discussion of milk and true sanitation means protection from disease germs. The entire omission of such safeguards in the above cards shows that a revision is desirable. Below is given a suggested milk score card indicating the principles which should enter into a proper milk score card.

Suggested score card for milk

	Perfect
Division I:	
Food value	
Fat	15
Solids not fat	10
Division II:	
Healthfulness	25
Division III:	
Cleanliness, visible dirt	25
Division IV:	
Keeping quality, flavor and odor	15
Bacteria	5
Acidity	5
	100

When the score of each division is 20 or above the milk is GOOD.
When the score of each division is 23 or above the milk is EXCELLENT.

A card like the above would assist in grading a city milk supply.

Report of committee on legal standard for ice cream. This report was prepared by Professor Ruehe and in his absence read by the secretary.

The report was referred back to the committee for further consideration.

Report by Professor Potts on dairy statistics.

This report was adopted, but has not been received by the secretary.

Reports on results of the dairy products judging contest by Professor White follows:

Awards

Team having highest grade on all products.—The National Dairy Association Cup: To Ohio State University.

Individuals having first, second, and third highest grades on all products.—The National Dairy Association medals: A. H. New, Ohio State University, Gold Medal; C. Farr, Iowa State College, Silver Medal; T. V. Armstrong, Ohio State University, Bronze Medal.

Team having highest grade on butter.—The J. G. Cherry Cup: To South Dakota State College.

Team having highest grade on cheese.—The Hoard's Dairyman Cup: To Ohio State University.

Team having highest grade on milk.—The J. B. Ford Cup: To Ohio State University.

Teams placing all products

	Grade
Ohio State University	8458.665
Maryland University	8393.874
Iowa State College	8393.758
South Dakota State College	8345.832
Purdue University	8251.374

Contestants placing all products

	Grade
1. A. H. New, Ohio State University	2836.583
2. C. Farr, Iowa	2834.500
3. T. V. Armstrong, Ohio	2822.666
4. J. H. Snyder, Maryland	2817.875
5. Geo. Biggar, South Dakota	2815.916
6. Chas. Reynolds, Maryland	2808.291
7. Homer J. Kline, Ohio	2799.416
8. D. A. Salisburg, Iowa	2796 250
9. Richard Gardner, South Dakota	2780.458
10. W. I. Poe, Purdue	2779 208
11. J. R. Graham, Maryland	2767.708
12. John A. Nelson, Iowa	2763 008
13. Clifford Peck, South Dakota	2749.458
14. G. J. Brown, Purdue	2736.166
15. Paul Blackburn, Purdue	2736.000

Report of team placing butter

	Grade
1. South Dakota State College	2895.0
2. Iowa State College	2887.0
3. Ohio State University	2887.0
4. University of Maryland	2879.5
5. Purdue University	2854.5

Report of team placing cheese

	Grade
1. Ohio State University	2730.000
2. Maryland University	2704.375
3. Iowa State College	2688.125
4. South Dakota State College	2682.500
5. Purdue University	2661.875

Report of team placing milk

	Grade
1. Ohio State University	2841.659
2. Iowa State College	2818.333
3. Maryland University	2809.999
4. South Dakota State College	2768.332
5. Purdue University	2734.990

Report of contestants placing butter

		Grade
1.	J. H. Snyder, University of Maryland	981 0
2.	Geo. Biggar, South Dakota State College	973 0
3.	D. A. Salisburg, Iowa State College	965 0
4.	C. Farr, Iowa State College	964 5
5.	A. H. New, Ohio State University	964 5
6.	T. V. Armstrong, Ohio State University	963 5
7.	J. R. Graham, Maryland University	963.5
8.	Richard Gardner, South Dakota State College	961 5
9.	Clifford Peck, South Dakota State College	960 5
10.	Homer J. Kline, Ohio State University	959 0
11.	John A. Nelson, Iowa State College	957 5
12.	W. I. Poe, Purdue University	954 0
13.	Paul Blackburn, Purdue University	951.0
14.	G. J. Brown, Purdue University	949 5
15.	Charles Reynolds, University of Maryland	936 0

Report of contestants placing cheese

		Grade
1.	Chas. Reynolds, Maryland University	925 625
2.	F. V. Armstrong, Ohio State University	917 500
3.	A. H. New, Ohio State University	913 750
4.	Richard Gardner, South Dakota State College	905 625
5.	C. Farr, Iowa State College	905 000
6.	J. H. Snyder, Maryland University	904.375
7.	W. I. Poe, Purdue University	904.375
8.	George Biggar, South Dakota State College	901.250
9.	Homer J. Kline, Ohio State University	898.750
10.	D. A. Salisburg, Iowa State University	898.750
11.	John A. Nelson, Iowa State College	884.175
12.	G. J. Brown, Purdue University	882.500
13.	Clifford Peck, South Dakota State College	875.625
14.	Paul Blackburn, Purdue University	875 000
15.	J. R. Graham, Maryland University	874.375

Report of contestants placing milk

		Grade
1.	C. Farr, Iowa State College	965.000
2.	A. H. New, Ohio State University	958.333
3.	Chas. Reynolds, Maryland University	946 666
4.	F. V. Armstrong, Ohio State University	941.666
5.	Homer J. Kline, Ohio State University	941.666
6.	Geo. Biggar, South Dakota State College	941.666
7.	D. A. Salisburg, Iowa State College	932 500
8.	J. H. Snyder, Maryland University	932.500
9.	J. R. Graham, Maryland University	930.833
10.	John A. Nelson, Iowa State College	920.833
11.	W. I. Poe, Purdue University	920 833

		Grade
12.	Clifford Peck, South Dakota State College	913 333
13.	Richard Gardner, South Dakota State College	913.333
14.	Paul Blackburn, Purdue University	910.000
15.	G. J. Brown, Purdue University	904.166

Moved by Washburn that ice-cream be included among the products for the dairy judging contest. Carried.

Moved, seconded and carried that a committee be appointed to discuss with Colonel Skinner, secretary of the Dairy Show the questions of increasing the number of medals for student judging contests. Carried.

The following were elected as officers of the manufacturing division: Roy Potts, chairman; W. P. B. Lockwood, vice-chairman; Rudnick, recording secretary.

Afternoon session adjourned.

Banquet

The annual banquet of the Association was held at the Hotel Sherman.

Our honored guest of the evening was President R. A. Pearson of Ames, Iowa, who gave us a very inspiring address.

Talks were also made by Dean Van Norman and Chief Rawl, two men who have during these past years been a source of strength and inspiration to the Association.

Chief Rawl moved that our Association go on record favoring an international dairy congress to be held in the fall of 1922. Carried.

The following committee was named with power to act, on matters pertaining to the dairy congress: Chief Rawl, Professor Eckles, Professor Breed, Professor Hunziker, C. E. Gray, Professor Mortensen, and Professor Erf.

Professor Frandsen gave an interesting talk regarding the Journal of Dairy Science.

The following resolution was passed:

The American Dairy Science Association urges the passage of laws by state legislatures to control the making of bacteriological analyses

where these are used as the basis of payment. These laws should be similar in general form to those already in force for the control of the butterfat test.

Banquet adjourned.

Minutes of the Meeting of the Advanced Registry Testing Section of the American Dairy Science Association, Held at Chicago, Illinois, October 11, 1920

The following men were present at the meeting:

H. P. Davis, Idaho	W. W. Swett, Missouri
C. H. Eckles, Minnesota	M. M. Regan, New Jersey
W. L. Gaines, Illinois	A. C. Ragsdale, Missouri
C. W. Larson, Washington, D. C.	Helmer Rabild, Washington, D. C
J. R. Dice, North Dakota	H. E. Van Norman, California
J. H. Frandsen, Nebraska	O. Erf, Ohio
J. A. Gamble, Maryland	T. M. Olson, South Dakota
C. E. Wylie, Tennessee	L. H. Fairchild, Indiana
J. M. Fuller, New Hampshire	J. B. Fitch, Kansas
E. B. Fitts, Oregon	B. R. Rogers, Chicago, Ill.
E. G. Woodward, Washington	R. H. Mason, Arkansas
C. W. Turner, Missouri	R. S. Hulce, Wisconsin
C. R. Gearhart, Kansas	M. H. Campbell, Illinois
C. A. Iverson, Iowa	A. A. Borland, Pennsylvania
F. W. Well, California	R. T. Harris, Wisconsin
W. J. Fraser, Illinois	M. H. Fohrman, Minnesota

Meeting called to order by the temporary chairman, Mr. Eckles.

H. P. Davis of Idaho was unanimously elected permanent chairman of the Section.

M. H. Fohrman of Minnesota was elected permanent secretary of the Section.

Motion made that a committee be appointed to draft rules of eligibility, officers, and all other matters necessary for the permanent organization of the Advanced Registry Testing Section of the American Dairy Science Association. Motion carried.

Chairman Davis appointed the following to act on this committee: E. G. Woodward of Washington, R. T. Harris of Wisconsin, W. J. Regan of New Jersey.

Report of the committee on relation to breed associations. This committee was made up as follows: C. H. Eckles, Minnesota (chairman); R. T. Harris, Wisconsin; W. W. Yapp, Illinois; H. H. Wing, New York; G. C. White, Connecticut; E. G. Woodward, Washington.

Chairman Eckles read the following report of this committee:

Report of the Committee on Relations to Breed Associations

At the last meeting of the Dairy Science Association a recommendation by this committee was adopted as follows:

> That the experiment stations or colleges in vouching for official tests, stamp each report with a statement exempting the institution from any legal responsibility for the accuracy of the tests.

The chairman of the committee was instructed to formulate with legal advice a proper statement for this purpose and to send a copy of this statement to each superintendent of official testing. This was carried out as directed. The statement as formulated was as follows:

> That this report is vouched for with full confidence in its accuracy, but is not guaranteed by the ———— and is subject to cancellation for error.

This statement is a modification of that which has appeared for several years on Holstein pedigrees. No information has been gathered as to how generally such a statement has been adopted by the various state superintendents.

The following resolution was also adopted:

> That the American Dairy Science Association recommend to the Association of Agricultural Colleges and Experiment Stations that all dairy breed associations be requested to relieve the colleges and experiment stations after October 1, 1920, of the supervision of official dairy tests where the test period is less than ten months in length.

The committee was directed to forward this resolution with a suitable explanatory statement to the executive committee of the American Association of Land Grant Colleges. Such a statement was proposed by the chairman of your committee and sent with the resolution to President Thompson of Ohio State University, the chairman of the executive committee.

His committee declined to consider the matter on the grounds that it is a local issue and therefore does not come within the field of their deliberations.

Following the annual meeting of the American Association, a new executive committee was appointed of which President Pearson of Iowa is chairman and President Riggs of South Carolina, President Stone of Purdue, Dean Russell of Wisconsin and Dean Mann, Cornell, members.

The matter was again presented to this new committee with the same results. Apparently this Association of Deans does not see fit to officially consider the problems of official testing. However, through the offer of a prominent dean to call a special conference for the purpose, an opportunity is offered of having our recommendations considered unofficially by a group of the deans most interested.

At a meeting of your committee last year, a subcommittee consisting of Harris of Wisconsin and Yapp of Illinois was appointed to consider the matter of financing official testing. During the year this subcommittee submitted a statement to the Dairy Breed Associations for their consideration and a recommendation concerning the matter is later presented for your consideration.

In preparation for this meeting, the chairman of your committee asked each superintendent of official testing to submit such matters as he desired for the consideration of your committee. A résumé of these suggestions was submitted to the committee for consideration and discussion. As a result of the deliberations of your committee, certain recommendations are submitted for your consideration. It is suggested that these recommendations be made the first order of business and that later opportunity be given for a general discussion of official testing problems, the suggestions presented to the committee to form a program for such discussion.

The following recommendations were made by the committee:

Resolution Number 1

WHEREAS: (1) In 1914 the American Science Association adopted the following statement concerning the relation of the agricultural colleges and experiment stations to the breed association in regard to official testing as follows:

> It is not the province of the agricultural colleges to undertake the control in any way of the rules and requirements for advanced registry adopted by the several breed associations. The interest of the colleges in this matter is purely an advisory one.

Inasmuch as the colleges are called upon to conduct the tests for advanced registry and to stand responsible for the accuracy of the results reported it is their right to formulate the rules governing the conduct of the tests and the work of the supervisors. The relation of the breed associations to this work is only an advisory one.

(2) The superintendents of official testing for the Holstein-Friesian, Guernsey, Ayrshire and Brown Swiss Breed Associations have by direct statement or by implication from the statement of their rules and from their attitude in dealing with state superintendents of official testing accepted the substance of this statement and recognize the full responsibility of the state superintendent of official testing for the conduct of all official testing in his state.

(3) The American Jersey Cattle Club has never in its dealings with the various superintendents of official testing conceded the full responsibility of the state superintendent for the conduct of tests in his state and have adopted certain rules in variance with the standard rules for the conduct of official testing approved by the American Dairy Science Association. These rules and this general attitude on the part of the Jersey Cattle Club has been the cause of much friction between the breeders and the superintendents of official testing.

For these reasons we request, and insist upon, the following action by the Jersey Cattle Club or by its superintendent of the register of merit.

1. The recognition of the full responsibility of the superintendent of official testing for the conduct of all tests within the state.

2. That the rules for the conduct of official testing as published in the handbook issued by the Jersey Club be modified to conform to the rules for the conduct of tests as approved by the American Dairy Science Association. In this connection we recommend, but do no insist upon the publication of these standard rules and the elimination of all other rules concerning the conduct of tests except such as may be deemed necessary to supplement these rules.

Resolution Number 2—Financing official testing

WHEREAS: (1) The rapid increase of official testing has placed a severe financial burden upon the experiment station or college taking the responsibility. Even when all charges are assessed to the breeder a large revolving fund or free balance is necessary, amounting to from $500 to $10,000 in different states. Many experiment stations are

finding it difficult to carry this burden. In the opinion of this Association this burden should be borne by the breed associations for whom the testing is done.

(2) The collection of bills for official testing by the superintendent of official testing causes more or less strained relations at times between his institution and the breeders, and furthermore under present arrangements the recourse of the superintendent of official testing in case of delay of payment of bills is inadequate.

For these reasons we ask the breed association to adopt the following plan:

1. The collecting of all bills for advanced registry testing be done by the national association for which the testing is done.
2. The state supervising the test to render a bill covering the cost of supervision to the national association. The same to be accompanied by the supervisor's authenticated report of the test.
3. The breed association to make payment direct to the experiment station immediately upon receipt of the test reports properly made and the bill properly rendered. Any errors to be corrected later.
4. The experiment station to be responsible for the accuracy of the bill rendered and any error or discrepancy on the part of the experiment station to be properly adjusted by them.

As a means of bringing this about we recommend

(1) A conference of the committee on relation to breed associations with representatives of the breed associations.

(2) That each superintendent of official testing be urged to bring the matter to the attention of the administration of his institution.

(3) That the matter be brought before a conference of deans and directors if found possible.

Resolution Number 3

This Association reaffirms its position as taken in 1913 and 1917 concerning the authentication of cow test association records. The resolution as passed at the eleventh annual meeting in 1917 was as follows:

It is the sentiment of this body that records supervised by cow testing association employees should not be authenticated unless the supervisor selected and employed by the superintendent of official testing in that state, and that the work be done in strict accordance with the rules adopted by the Official Dairy Instructors' Association for the conduct of official tests, and further that even in

states where cow testing association records are authenticated under these conditions the practice should be discontinued as promptly as more satisfactory arrangements can be made.

The committee on relation to the breed association is directed to call the attention of all deans of agricultural colleges and superintendents of official testing to this recommendation of the American Dairy Science Association.

In addition the committee recommends that after these matters are considered and acted upon, a general discussion be held of other matters concerning official testing.

Eckles moved that the recommendations of the committee on relation to breed associations be adopted as read. Seconded.

Discussion followed.

Eckles called attention to the action taken by this Association in 1914 defining the relation of the colleges and breed associations regarding testing which is set forth on pages 4 and 5 of the printed report of committee on relation to breed associations and is as follows:

It is not the province of the agricultural colleges to undertake to control in any way the rules and requirements for advanced registry adopted by the several breed associations. The interest of the colleges in this matter is purely an advisory one.

Insomuch as the colleges are called upon to conduct the tests for advanced registry and to stand responsible for the accuracy of the results reported it is their right to formulate the rules governing the conduct of the tests and the work of the supervisors. The relation of the breed associations to this work is only an advisory one.

He also called attention to a recent change in the rules of the American Jersey Cattle Club governing the supervision of register of merit tests, regarding the number of cows to be supervised at one time.

Relative to financing official testing, the committee suggests that the breed associations carry the burden.

Attention was called to the fact that in some states there is dissatisfaction brought about through the acceptance of cow test association records in neighboring states.

At this point Mr. H. E. Van Norman requested the body to consider whether or not it would be desirable for the dairy interests to take the initiative in holding a world's dairy congress in this country for the consideration of all phases of the dairy industry: the expenses to be provided for by Congress and the dairy industry.

It was moved that this Section concur in making this matter a special order of business for the evening meeting of the American Dairy Science Association as a whole. Carried.

The meeting proceeded to further discussion of the recommendations of the committee.

Regan of New Jersey suggested that a definite stand should be taken against the action of the American Jersey Cattle Club in sending a check supervisor into a state without the consent of the college, and also that the colleges should oppose the change in their rules regarding the number of cows to be milked at one time. The colleges should insist that the American Jersey Cattle Club recognize the superintendent of official testing as the man who has control of official testing in the state when it comes to rules that directly affect the authentication of the test.

Fohrman of Minnesota recommends that the American Jersey Cattle Club be requested to change their rules governing the supervision of the test to conform to those of the American Dairy Science Association.

Fitch of Kansas expressed the same sentiments.

Regan inquired as to what method would be used to put the matter up to the American Jersey Cattle Club.

Eckles said this matter would be handled by the committee on relation to breed associations.

Woll of California agrees that the superintendents should be in absolute control of the tests, but the matter of preliminary milkings should be left to the breed associations.

Regan inquired how many other states besides California were varying from the American Dairy Science Association rules.

Indiana: No preliminary milking required.

California: No preliminary milking required and breeders allowed to milk two cows at a time.

Washington: No preliminary milking required.

Tennessee: No preliminary required on Jerseys.

Arkansas: No preliminary required.

North Dakota: No preliminary required.

Ohio: The superintendent uses his discretion regarding preliminaries.

Idaho: Follow rules of breed associations on preliminaries.

Iowa: The superintendent uses his discretion regarding preliminaries.

Regan suggested that the colleges agree unanimously to follow the rules of the American Dairy Science Association, and that if these rules need revision, proper action be taken.

Fuller of New Hampshire recommends that all Stations adopt the uniform rules of the American Dairy Science Association.

Erf of Ohio suggests a conference between representatives of the colleges and breed associations. All colleges should agree to one general plan of action, and if a meeting of the breed associations could be called and the matter laid before them, they would all adopt these rules.

Ragsdale moved that the original motion be amended and that the first recommendation of the committee be approved as read. Motion carried.

The second recommendation of the committee on relation to breed associations was taken up for consideration.

Recommendation read by the secretary.

Motion made by Regan of New Jersey that the second recommendation be adopted as read. Seconded.

Discussion of plans for financing official testing.

Fohrman briefly outlined a plan which had been discussed at a meeting of representatives of the breed associations of having a committee in each state composed of representatives of each breed to lobby for an appropriation by the state legislatures of a sufficient fund to be used as a revolving fund to finance the official testing in the various states.

Davis suggested a regional plan for supervising official testing, the work to be subsidized by all breed associations with a superintendent in charge of each region, to consist of a single state or group of states, according to the volume of business.

Fuller raised the question, "is advanced registry testing educational or commercial."

Regan replied that in Nevada he considered it educational but in New Jersey commercial.

Eckles stated that the deans of some of the colleges are asking if official testing is a college function.

Fitch said that during his ten years in Kansas he considered official testing educational for the first six or seven commercial for the last three or four.

Erf of Ohio advised that when no funds were available to take care of official testing bills in his state the breed associations brought pressure to bear on the legislature to provide necessary funds.

Davis feels that the breed associations should assume more financial responsibility for official testing and should be compelled to do so.

Motion to adopt the second recommendation of the committee was carried.

The third recommendation of the committee was read by Chairman Eckles and discussion opened.

Erf of Ohio, outlining the work as carried on in his state, said that all supervisors are civil service men and must pass an examination. When a cow test association employs a civil service man he has the right to devote part of his time to official test work. It is not a combination of official and cow test association, but the same man is used for both, provided the cow test association will employ a civil service man. Ohio does not authenticate cow test association reports as official.

Davis of Idaho said that with one exception all testing in his state was carried on through cow test associations. This allows men to do official testing work in widely scattered communities. Every cow tester is approved by the man in charge of official testing and required to pass an examination on official testing. The time he devotes to official testing he is in the employ of the college and paid by the college and responsible to the college. Men are changed from one association to another. Colleges have reserved the right to see that three different men supervise work during the year.

Fuller reported that New Hampshire has a similar arrangement to that of Idaho.

Rabild stated that while the supervision of official testing is entirely in the hands of the colleges, it will help cow test association work if such combinations are permitted.

Moved and seconded that the third recommendation of the committee be adopted. Carried.

Moved and seconded that the recommendations adopted be adopted entire. Carried unanimously.

Motion made by Regan that any superintendent of official testing that finds a herdsman or supervisor who is dishonest should report that fact at least to adjoining states and to the superintendents of the various breed associations, with request that they report to parties in any state who may be interested. Seconded and carried.

Gamble of Maryland moved that the secretary gather information in regard to charges for official testing, pay of supervisors in the different states, etc., and submit this information to the various colleges. Motion seconded and carried.

Erf of Ohio suggests that the state breed associations appoint one man each to select a superintendent of official testing who would have charge of the supervisors of the state and vouch for the records.

It was moved that the suggestion be made on the reports of the committee to the breed associations that they adopt a uniform blank for reporting official tests. Seconded and carried.

A general discussion was held of topics of interest to superintendents of official testing and parties connected with test work at the colleges. There were exchanges of ideas and experiences, and suggestions for improving the work.

Adjournment followed.

M. H. Fohrman,
Secretary.

OPEN FORUM

The following letter describes very vividly conditions said to maintain in Hungary at this time I thought possibly some of the members of the American Dairy Science Association would find it possible to give assistance of one kind or another, and I am therefore publishing the letter in full

J. H. Frandsen,
Editor-in-Chief.

M. Kir. Tejkiserleti Allomas.

To the

American Dairy Science Association:

Sir!

The present condition and the future of the Hungarian scientifical institutions as well as of the Royal Hungarian Dairy Experiment Station is perhaps you know it extremely desolate. The utensils necessary to scientifical researches, our chemicals, books and periodicals are mostly of foreign origin and can not be bought nor repaired in consequence of the low state of the financial standard and because the revenues of the Experiment Station are very small. We are prevented to read foreign journals and to learn anything about the progress of modern science. The Hungarian state became poor and unable to raise our income according to the present immoderate prices. Our station receives for its purposes no more than 10,000 crowns yearly; from this small sum we are to pay also our employees, from this we must provide for heating, lighting, for the requirements of the laboratories. To do all this is quite impossible.

Beside that the Dairy Experiment Station has been entirely knocked down by the Roumanian invasion. In the year 1919 at spring time it was transferred to the environs of Budapest in order to accomplish better its scientifical aims. The fittings of the laboratory were not as yet unpacked when the Roumanian invaders came in our country and took all we have had with the only exception of the furniture and of the library. We were obliged to return to Magyarovar completely despoiled by the plunder. We have lost all the chemical and bacteriological utensils of the laboratory and partly our apparatuses.

By this deprivation the Station became lame. Without kind help we are for long time excluded from every scientifical progress, we have

taken part of before the war as demonstrated by some subjoined prints of our scientifical records. Old merry Hungary exists no more rent into pieces, important dairy districts point of view are given to the surrounding nations. In consequence thereof the support of the Station granted by the state grew insignificant.

Notwithstanding we desire to work, we desire to be useful in science. But whereof may we want for help? To whom may we apply? It is sorry, we want the support of foreign countries, because we have nothing. The generous people of the United States of America has done very much good for our country and for our people while the war endured it can help us easily. The low value of the Hungarian crown makes it possible that a comparatively small sum of your grew to a very important one when taken in our value.

We request of your benevolence, in name of the Royal Hungarian Dairy Experiment Station to take your part in supporting our scientifical inquiries relating dairy. Your help might consist either in financial aid or in sending utensils required to experiments, in prints of the American experiment Stations journals, newspapers, new books related to dairying. To avoid the eventual receipt of materials unwished for it was advisable to communicate our needs to you.

We recommend once more our petition to your benevolence.

Respectfully,

ROYAL HUNGARIAN DAIRY EXPERIMENT STATION,
M. KOR. TEJKISERLETI ALLOMAS.
Magyarovar.

THE INFLUENCE OF CALCIUM AND PHOSPHORUS IN THE FEED ON THE MILK YIELD OF DAIRY COWS

EDWARD B. MEIGS AND T. E. WOODWARD

From the Research Laboratories of the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, Washington, D. C.

Opportunities for observing the effects of food on milk secretion have been rather favorable on the United States Experimental Farm at Beltsville, Maryland, where the authors are stationed. There has been maintained here since 1912 a herd of from 50 to 100 cows, some of which are pure bred Guernseys, Jerseys, and Holsteins; and some, grades. Daily records have been kept of the milk yields throughout, and yearly records of the amounts of food consumed up to 1918. Since 1918, monthly or daily records of the rations have been kept. The fat has been determined in the milk of each cow once a month, and from the results so obtained the monthly and yearly yields of fat have been calculated. The foods chiefly used have been corn meal, wheat bran, cottonseed meal, linseed meal; alfalfa and other legume hays; and corn silage and stover. Most of the cows have had a little pasture in the summer, but not enough to make up any considerable proportion of the total amount of food eaten in the year.

The aim has been to feed the cows as much protein as is required by the most liberal of the American feeding standards, to keep them in good condition, to have them calve once a year, and to have them dry for six or eight weeks each year before calving. It has generally happened in practice that the cows were fed a little less liberally than is demanded by the Savage and Eckles standards (1) for the first two or three months after calving, and a little more liberally later. When they were dry, they were usually fed 4 pounds of grain B,[1] 4 pounds of legume hay, and as much silage as they would clean up. When the hay

[1] See table 1, Grain mixtures used in experiments.

was alfalfa, and the amount of silage eaten daily 30 pounds, which was the most usual state of things, this ration provided 1.29 pounds of digestible crude protein and 10.29 pounds of total digestible nutriment daily. After subtracting the maintenance requirement for a 1000-pound cow, this would allow 0.59 pound protein and 2.37 pounds total nutriment daily for the growth of the unborn calf, which, according to the results obtained by Eckles (2), ought to be sufficient.

We have recently calculated the protein and total nutriment in the yearly rations of a number of cows from the general herd and have compared these quantities with those required for their maintenance and for their milk and fat yield according to the Savage standard. The results have shown that the cows usually received rations a little more liberal than those demanded by this standard.

During the last two years a number of the pure bred Holsteins have been run on official test. In order to increase their milk yield, their rations were made decidedly more liberal than those called for by any of the feeding standards. During the time that they were milking they received daily about 12 pounds of alfalfa hay, 20 pounds of corn silage, and as much grain as they could clean up without getting sick; they usually ate 18 to 20 pounds a day of grain F. They were fed heavily also before their calves were born. For sixty days or more before calving they usually received about 15 pounds of grain F, 12 pounds of alfalfa hay and 25 pounds of corn silage. This ration contains approximately 4 times as much protein and two and one-half times as much total nutriment as the routine ration fed to the dry cows of the general herd.

The test cows gave from 15,000 to 20,000 pounds of milk in the year, that is, three to four times as much as most of the cows in the general herd. A part of this larger yield is due to the fact that the test cows were better bred, but a part is also due to the larger quantity of feed that they obtained. How much of the increased milk yield ought to be attributed to each of these factors is a question of great practical interest.

The cycle of lactation consists of two phases which may be called the preparatory and the active phases. Considerable changes go on in the udder of a cow for some time before her calf is born, and usually make themselves manifest by an increase in size and congestion of the organ. There is no doubt that the amount of the subsequent milk yield is largely dependent on these changes, and it is highly probable that the changes themselves are dependent on the state of nutrition in which the animal happens to be for the few weeks before her calf is born.

It is well known that animals are capable of storing up large quantities of nutritive material in their bodies in times of plenty and using these stores in times of stress. The effect of food on milk secretion may, therefore, often be long delayed and rather complicated. It is not at all impossible that the effects of a deficient ration supplied in one lactation period may not show themselves until the subsequent period or even later.

Figures 1 and 2 give graphically the histories of two cows which were brought to the Beltsville farm some years ago, and fed and treated according to the usual routine. The milk yields fell off very noticeably during the routine treatment. After several years of the routine treatment, no. 17 was given an unusually long dry period before calving, and no. 201 a more liberal ration for some weeks before calving. In both cases the subsequent milk yields were markedly increased.

The increases in the milk yields are to be attributed in the one case to the more liberal ration supplied before the calf was born; and in the other case to the long dry period with a super-maintenance ration. The rations fed after calving bore about the same relation to the milk yields as they had in previous years. It may be added that the milk yield for the first few weeks of lactation is not very closely dependent on the contemporaneous food supply (10).

The course of events illustrated by the cases of cows 17 and 201 is not exceptional, but typical. Several other similar histories could be presented. Indeed, it has been the regular rule on this farm that greatly increased milk yields were obtained when cows from the general herd were dried off two months or

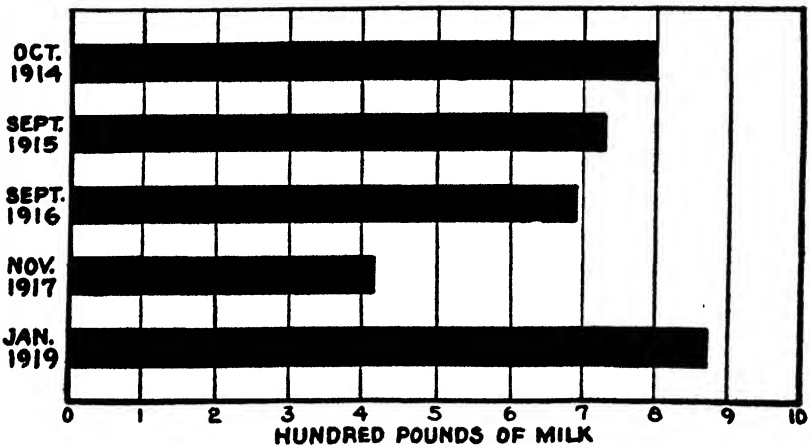

FIG 1. THE INFLUENCE ON THE LENGTH OF THE DRY PERIOD ON THE SUBSEQUENT MILK YIELD IN THE CASE OF COW 17

The columns represent the pounds of milk given in the first clear calendar month after calving in the years indicated. Before calving in the years 1914 to 1917 inclusive, this animal was fed the routine ration devised for the dry cows at Beltsville; her dry periods averaged 44 days. Before calving in December, 1918, she was given a dry period of 122 days and fed approximately as in her previous dry periods. See p. 199.

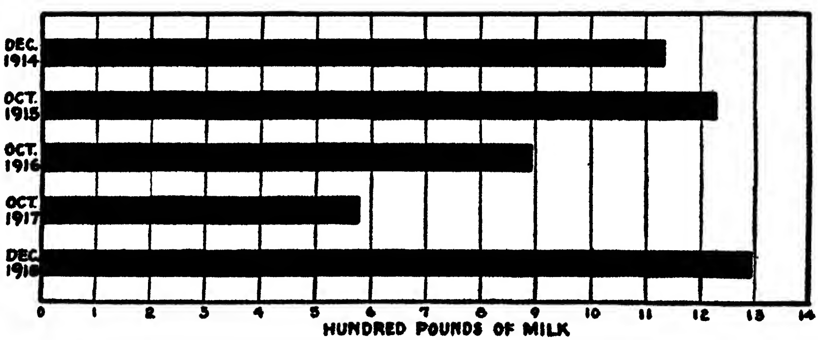

FIG. 2. THE INFLUENCE OF THE LENGTH OF THE DRY PERIOD AND OF THE RATION FED DURING THAT PERIOD ON THE SUBSEQUENT MILK YIELD IN THE CASE OF COW 201

The columns represent the pounds of milk given in the first clear calendar month after calving in the years indicated. Before calving in the years 1914 to 1917 inclusive, this animal was fed the routine ration devised for the dry cows at Beltsville; her dry periods averaged 50 days. Before calving in December, 1918, she was given a dry period of 78 days, and during the last 40 days of this period was fed a much more liberal ration than the previous one. See p. 201.

more before they were due to calve, and fed liberally during this period. Cows 17 and 201 were selected as examples, not because the downhill course of the milk yields on the routine treatment were particularly rapid; or the subsequent recoveries, particularly marked; but simply because they have been freer from disease and from disturbing experiments during their stay at Beltsville than the other examples which might have been selected. It is, therefore, a very moderate statement of the case to say that average and high producing cows are often,[2] not kept up to anything like their optimum milk yield when they are bred to calve once a year and fed for several years approximately according to the most liberal of the American feeding standards, even though they may get a little pasture in addition. Under this treatment the milk yield may often be reduced, after a few years, to less than half the optimum; and, after it has been so reduced, it may be very greatly increased by liberal feeding during a two months' dry period. A point of great interest to be noted in the history of cow 201 is the length of time which it took for the full effects of the routine method of feeding to become apparent. The milk yield did not reach its lowest point until she had been on the farm for four years.

THE NATURE OF THE DEFICIENCY IN THE ROUTINE RATIONS FED AT BELTSVILLE

It is not improbable that the rations fed at Beltsville were not generally deficient, but deficient only in one or a few particular constituents necessary for milk secretion. The cows were kept in good general condition, which seems to indicate that they received enough of the energy yielding portion of the ration. The recent very interesting work of Forbes (3) indicates that liberally milking cows may often receive insufficient calcium and phosphorus in their rations; the further experiments which we

[2] Our evidence shows only that cows are not kept up to their optimum milk yield when fed the protein and total nutriment required by the standards in the form of the amounts of grain, hay, and silage used on the Beltsville farm. The reader must judge for himself how closely this method of feeding approaches what is typical throughout the country.

have to report were directed toward throwing more light on this question.

There is little doubt that a cow's milk yield is markedly influenced by the nutriment which she receives during the six or eight weeks before her calf is born. The experiments to be reported have, therefore, been confined to the influence of the ration fed during this period on the subsequent milk yield; and, for the reasons given below, the phosphorus fed during the dry period has been varied rather than the calcium.

The results of certain metabolism experiments in which the calcium and phosphorus balances have been followed—particularly those of Forbes (3) and Hart (4)—seem to show that calcium and phosphorus metabolism are largely independent of each other. But in these experiments the calcium and phosphorus balances have not been followed for more than twenty days successively. There is no reason to doubt the figures that have actually been obtained, and it is very likely that a cow may lose 200 or 300 grams of calcium while remaining in phosphorus equilibrium. But it is doubtful whether the metabolic independence of the two elements ever goes much further than this. In a recently published article this question has been discussed in some detail, and it has been pointed out that the weight of evidence obtained from carcase analyses is strongly against the view either that the ratio Ca: P in bone is subject to more than very small variations or that the concentration of either of these elements contained in any of the soft tissues undergoes more than insignificant changes. Evidence was also adduced to indicate that calcium assimilation in cows is likely to be seriously interfered with for a period of at least eight days by the mere collection of their urine and feces by attendants as practiced in the experiments of Forbes, of Hart, and of ourselves (5).

It is likely, therefore, that any considerable deficiency of either calcium or phosphorus in the rations of a milking cow will bring about the loss of both elements from the animals' bones if continued for more than two or three weeks, and that a cow which has suffered from the lack of either during any considerable part of her lactation period will find herself depleted in both when she reaches the end of that period.

In recently published articles from this laboratory (6) it has been shown that the phosphorus content of the blood plasma of cows is highly variable, and that it is likely to be low in the plasma of the Beltsville cows toward the end of their periods of pregnancy. This suggests that the cows of the Beltsville herd usually reach the end of their lactation periods with their phosphorus stores depleted, and that the rations fed during the dry period are not sufficient to restore them. For the reasons which have been given above, it is likely that the calcium stores of the Beltsville cows are also depleted during their lactation periods; and that neither the calcium nor the phosphorus stores can be restored to their proper level during the dry period, unless the cows are fed rations which make it possible for them to assimilate liberal quantities of both elements.

In the articles from this laboratory above referred to, certain other facts regarding calcium and phosphorus metabolism were brought to light. It was shown that the concentration of calcium in cows' blood plasma is much more constant than that of phosphorus. It is usually easy to raise the concentration of plasma phosphorus by increasing the amount of phosphorus in the rations —either by feeding more grain or by adding sodium phosphate to the ration. But the changes brought about in the concentration of plasma calcium by analogous procedures, or by any other influences that we have encountered so far, are comparatively insignificant, and usually fall within the limits of error of our determinations.

It has seemed likely, therefore, that changing the amount of phosphorus in the ration would have more immediate and easily determinable effects on the changes which go on in a cow's udder shortly before her calf is born, than changing the amount of calcium. The experiments to be reported were planned with this idea in mind. But it was essential that both the control and the experimental animals should have plenty of calcium in their rations and they, therefore, all received alfalfa hay in quantities which it was hoped would provide sufficient calcium for their needs. The details of the experimental procedure and the results obtained are given in the description and tables at the end of the article.

The experiments consisted essentially in drying cows off about sixty days before they were due to calve; in feeding some of them (the controls) a certain basal ration; in feeding the others (the experiments) the same basal ration, but with the grain and hay fed on alternate days[3] and with sodium phosphate added to the grain; and in following the milk yields from the tenth to the fortieth day after calving.

Some of the animals used in the experiments were from the general herd, and had previously been fed approximately according to the Savage feeding standard. Others had been on test during the year preceding the experiments, and had been fed much more liberally. In the case of the animals from the general herd (tables 2 and 3) the alternated feeding with phosphate had a very favorable influence on the subsequent milk yield; in the case of those which had been on test (table 4), the effect was insignificant. This indicates that the rations fed to the general herd were deficient in one or both of the principal bone-building elements.

The results show that the effect of the alternated feeding with phosphate on the subsequent milk yield will depend on the previous history of the cows studied as well as on the amount of phosphorus contained in the basal ration. It follows that the quantitative results of the experiments are significant only for the special conditions under which they were carried out. They might be entirely different in a herd whose previous history had been different, or with a basal ration which contained a different amount of phosphorus.

The attempt has been made, however, to get an approximately quantitative idea of the increase in milk yield produced by the phosphate feeding under the conditions of experimentation used with the cows of the general herd. For this purpose only those animals have been considered which figure both as controls and experiments, and whose histories are given in table 2. The method and results used in this attempt are given in table 9 with its appended comment and in figure 3. The animals gave,

[3] See description of experiments, p. 203.

on the average, 37.9 per cent more milk after the phosphate feeding than would have been expected from their previous performance.

The milk yield from the tenth to the fortieth day after calving has been taken as the most important measure of the effects produced by the alternated feeding with phosphate during the

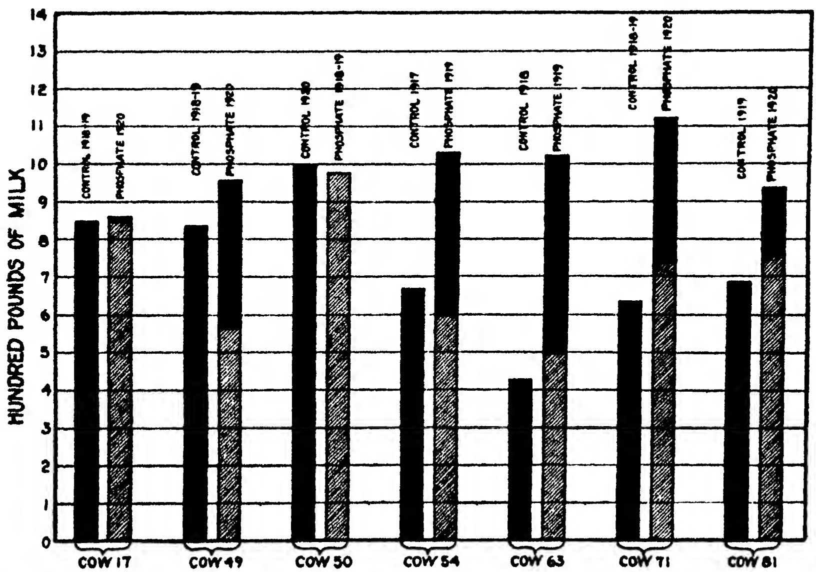

FIG. 3. COMPARISON OF MILK YIELDS OF GRADE COWS FROM THE GENERAL HERD AFTER CONTROL AND PHOSPHATE FEEDING

The columns show the amounts of milk given in 30 days soon after calving; the lighter portions of the columns show the amounts of milk to be expected after the phosphate feeding, using the yields after the control feeding as a basis, and taking into account the facts that the animals were generally older during the experimental feeding, and that some of them aborted. See pp. 208–210 and p. 215.

preceding dry period. But certain other aspects of the effects produced by this treatment have also been studied.

Both the animals on the experimental feeding and those used as controls were weighed from time to time. We do not wish to lay too much stress on the results obtained, because the manner in which an animal gains weight in the period of a month or so before it calves depends almost as much on its previous

history as on the ration fed at the time. The results in question are given in the description of the experiments, pp. 212 to 215, and in tables 5, 6, 7, and 8. They are rather irregular, but indicate, on the whole, that the animals on alternated feeding with phosphate made somewhat better gains than the controls.

In a previous publication from this laboratory (5), a balance experiment was described in which the animals received alternated rations with phosphate for a part of the time. The alternated feeding with phosphate had no perceptible effect on the amount of urine or feces voided or on the water content or consistency of the feces.

We have the impression that the increase in size of the udder which occurs before calving has generally appeared earlier and has been more marked in the animals which have received the phosphate than in the controls. There have, however, been exceptions to this rule, and we do not feel inclined to insist very strongly upon it. We realize keenly the difficulty of judging accurately in such a case where no exact measurements are taken.

DISCUSSION

Our results indicate that the milk yield of the general herd at Beltsville has been reduced by an insufficiency either of calcium, of phosphorus, or of both in the rations, in spite of the facts that these contained more than the average proportions of both calcium and phosphorus and were fed in the amounts required according to the feeding standards. We think it is still an open question whether calcium or phosphorus has been the element chiefly lacking, and whether the rations could be improved from the standpoint of mineral nutrition by varying the proportions of the different feeds used. Work aimed to throw light on these problems is now being carried out here. In the mean time, however, it seems worth while to consider the results in so far as they indicate what ought to be done with the knowledge already at hand.

Table 2 contains the cases where a cow's record after the phosphate feeding is compared with a previous record of her

own made after a period on the basal ration. It will be noted that in most of these cases the basal ration was fed before the first calf was born. The results as given in this particular table, therefore, are chiefly evidence for the view that the heifers received insufficient calcium or phosphorus in the rations supplied to them before they had their first calves.

We believe that this was the case and we shall later discuss the rations supplied to the heifers which had never had calves. But the records for the general herd indicate that, under the Beltsville routine, the animals never recovered from the mineral shortage which made itself evident in the first lactation period.

The evidence from the records which indicates this may be summed up as follows: In the case of the animals born at Beltsville and kept under the routine treatment there was no tendency for the milk yield to rise after the first lactation period to the extent that it did in the cases of nos. 54, 63, 71 and 81, shown in table 2. The rise as between the first and subsequent lactation periods was approximately that which would be expected from the data collected by Pearl and Patterson (7), and by the Holstein and Guernsey breeding associations. In the case of animals brought to the farm from other places and kept under the routine treatment, there was frequently a tendency for the milk yield to fall off more rapidly than it should with advancing age, as in the cases of cows 17 and 201, figures 1 and 2.

As many of the cows which received the alternated rations with phosphate received a basal ration somewhat lower than that fed to the general herd during their dry periods, it is not unfair to compare the milk yields of these two sets of animals. Cows 49, 54, 71 and 81 may be taken as representing the effects of the phosphate feeding in the case of grade Guernseys. In a period of thirty days soon after calving, these animals gave 1009 pounds of milk on the average. Their records may be compared with those of the other grade Guernseys of the herd, selecting lactation periods later than the first and in which there was no suspicion of abortion or other disturbing disease, and using the best month's milk yield in each lactation period as the figure to be compared with that given above. There are four

animals with a total of eight lactation periods available for the comparison, and the average best month's milk in the eight lactation periods was 660 pounds. As the grade Guernseys available for this comparison were rather few, the same calculation was made for the grade Jerseys. There are 16 animals with 52 lactation periods available in this case. The average best month's milk is 722 pounds. The grade Holsteins are not sufficiently numerous to give figures of any value.

No cow among the grade Jerseys and Guernseys of the general herd has ever surpassed the thirty day record of cow 71. In only one case has the average thirty day record given for cows 49, 54, 71 and 81 after the phosphate feeding, been surpassed, namely, with a best month's milk yield of 1041 pounds given by one of the grade Jerseys. In only five cases has the lowest thirty-day record among these four cows been surpassed, namely, by best month's milk yields of 1041, 988, 987, 1004 and 943 pounds respectively.

The results show, therefore, that the cows of the general herd at Beltsville suffered from an insufficiency of either calcium or phosphorus or both in their rations throughout their lives, both before their first calves were born and afterward. The following shows how they were fed, a little more in detail than has been done heretofore.

The young stock generally received milk until they were six months old or more. The feeding of grain, hay and silage, however, was started before the end of the first month and gradually increasing quantities of these foods were given until, at the end of six months the calves were taking 3 pounds of grain, 3 pounds of legume hay and 10 to 20 pounds of corn silage. After they were taken off milk, the calves were usually fed 3 pounds of grain, 3 pounds of legume hay and as much corn silage as they would clean up. The grain most used was grain E (see table 1). If they ate 25 pounds of corn silage daily which may be taken as a fair average, this ration would supply 0.94 pound digestible protein daily and 8.16 pounds total digestible nutriment. This is approximately the protein requirement given in the Wolff-Lehmann feeding standards for growing dairy cattle, and somewhat more than the requirement for total nutriment (8).

The manner in which the cows were fed and treated after their first calves were born, and subsequently, has already been discussed at some length (pp. 185 to 186). It is only necessary to add a word about the actual amounts of grain, hay and silage given. The manner in which the mature dry cows were fed has already been given (p. 185). The mature milking cows were generally fed 1 pound of grain B or C, to 3 pounds of milk, 6 or 8 pounds of legume hay, and as much corn silage as they would clean up. They usually gave about 25 pounds of milk a day when they were fresh, and, at this period they commonly got 8 pounds of grain B, 8 pounds of legume hay and 30 pounds of corn silage. They usually got a little thin with the progress of their lactation, and were then fed somewhat more grain in proportion to the milk yield. In the course of the year, as has already been stated, they got a little more protein and total nutriment than is required by the Eckles or Savage feeding standards.

The bone-building elements can probably be supplied in sufficient quantity in two different ways—either by feeding the ordinary materials much more liberally than the feeding standards require or by adding calcium and phosphorus in the form of inorganic salts directly to the rations. We have entire confidence that the latter method will finally be adopted and will effect a great saving in the cost of producing milk.

But so radical a change in feeding practice ought perhaps to be introduced slowly and with caution; the more conservative dairymen will probably prefer to keep to the ordinary farm feeds until the effects of feeding inorganic salts of calcium and phosphorus have been more fully worked out by the experiment stations.

Our experience at Beltsville indicates that with many cows a liberal ration fed for four to six weeks before calving easily pays for itself through the increased flow of milk in the subsequent lactation period, and we think that there are many cows throughout the country which are far more valuable than their owners suppose them to be. Those dairymen who have been feeding their animals according to the standards or less, should try out

their herds by giving each cow a period of two months dry and feeding her during that period three or four times the protein and two or three times the total nutriment required for maintenance, using feeds which contain plenty of calcium and phosphorus—legume hay and a liberal proportion of bran and cottonseed or linseed meal. If they find that the milk yield of any of their cows is doubled by this process, they will run no risk of reducing their profits by feeding those cows even 50 per cent more nutriment in the course of the year than the feeding standards call for.[4]

There is one other aspect of the case which must be discussed. Quite apart from the question of the feed cost per pound of milk when a cow's yield is reduced by feeding her a ration deficient in one or more necessary constituents is the question of the effect of this process on her capacity to resist disease. The Beltsville herd has suffered severely in the last three years from contagious abortion. The relation between the incidence of this disease and the manner in which the cows have been fed is being carefully studied at present, and the results of this study will be reported later. The results already obtained, however, are sufficient to justify a strong suspicion that abortion has occurred more frequently among the animals that were less adequately fed. But, whatever the final results of this study may be, it is obviously bad practice to allow a cow to deplete her body stores of important materials for long periods of time, even though milk may thereby be temporarily more economically produced. The ideal method is clearly to keep the yearly supply of raw materials in the food equal to the demand for milk production.

[4] Feeding cows heavily before they calve, of course, introduces the risk of milk fever. But if this disease is properly treated, the mortality is not high, and there are no enduring bad effects. A well run dairy should be equipped for dealing with milk fever. Our experience at Beltsville shows that the risk even of the appearance of the disease is not very great. In the last five years there have been something over 30 cases of cows fed two to four times the maintenance requirement of protein and total nutriment before they calved, and milk fever has appeared only twice. One of these cases was in a young cow, but was mild; the other was in a cow 15 years old.

SUMMARY

1. Feeding cows for several years according to the commonly accepted standards with little or no additional pasture, may result in their milk yield being reduced much below the optimum. The condition of reduced milk yield so brought about may be corrected by giving the animal a dry period of two months, and feeding during that period a ration containing legume hay and grain with a high phosphorus content and with three or four times the amount of protein required for maintenance, and two or three times the total nutriment. The milk yield in the subsequent lactation period may sometimes be doubled by this treatment.

2. In the case of cows of which the milk yield has been reduced by several years' standard feeding, a greatly increased yield can be brought about by feeding "alternated rations with phosphate" during the dry period. This is taken to mean that the ordinary rations are more likely to be deficient in one or both of the principal bone-building elements than in any other constituent.

In conclusion we wish to acknowledge the valuable services of Messrs. H. J. Nedrow, H. T. Converse, and W. E. Benscoter. Messrs. Nedrow and Converse were the herdsmen at the Beltsville farm during the period when the experiments were carried out and supervised the feeding and care of the experimental animals. Mr. Benscoter was responsible for the feeding in a number of cases, and carried out this part of the work with unusual care and accuracy.

DESCRIPTION OF EXPERIMENTS

Results showing the effects on milk yield of liberal feeding during the dry period

Cow 17. This animal was a grade Jersey born in 1909 and brought to Beltsville in 1912. The protein and total nutriment contained in her rations during the years 1914, 1915, 1916 and 1917 were calculated and compared with the quantities required for her maintenance and for her milk and fat yield according to the Savage standard (9), and it was found that she received on the average a surplus of about 10 per

cent of protein and of about 2 per cent total nutriment. It may be considered, therefore, that she was fed as nearly according to this

TABLE 1

*Grain mixtures used in experiments**

GRAIN A		GRAIN B	
	pounds		*pounds*
Corn meal	45	Corn meal	40
Wheat bran	36	Wheat bran	40
Cottonseed meal	18	Cottonseed meal	20
NaCl	1	NaCl	1
GRAIN C		**GRAIN CP**	
Corn and cob meal	45	Grain C	100
Wheat bran	36	Na_2HPO_4 $12H_2O$	11
Cottonseed meal	18		
NaCl	1		
GRAIN CP1		**GRAIN CP2**	
Grain C	100	Grain C	100
Na_2HPO_4 $12H_2O$	10	Na_2HPO_4 $12H_2O$	6
GRAIN D		**GRAIN DP**	
Hominy grits	45	Grain D	100
Ground oats	36	Na_2HPO_4 $12H_2O$	19
Cottonseed meal	18		
NaCl	1		
GRAIN E		**GRAIN F**	
Corn and cob meal	55	Ground oats	28
Wheat bran	30	Linseed meal	20
Linseed meal	15	Cottonseed meal	10
NaCl	1	Gluten feed	14
		Hominy feed	14
		Wheat bran	14
		NaCl	1

* The cottonseed and linseed meal used in these mixtures were meals from which the fat had been extracted by the old process: heat and pressure without solvents.

standard as is possible under any ordinary conditions. She was on pasture for only 7 days during the four years under consideration.

She had a calf toward the end of the summer of each year; the 1917 calf was born six weeks ahead of time, but it survived, and is still alive and well (June, 1920). The other three calves were all born normally. Her dry periods were 44 days on the average.

In 1914, she gave 5709 pounds of milk; in 1915, 5121 pounds; in 1916, 5056 pounds; in 1917, 4693 pounds; and in 1918, 2569 pounds.[5] In 1918, she was given a dry period of 122 days, with approximately the same ration as in previous dry periods. She calved December 11, 1918, and her milk yield for 1919 rose to 5578 pounds.

During her dry periods in 1914, 1915 and 1917, she was fed 4 pounds of grain B, 4 pounds of legume hay. and 30 to 35 pounds of corn silage. During her dry period in 1916, she received 4 pounds of grain B, 3 pounds of oat hay, 28 pounds of corn silage, and had 7 days on pasture. During the last 53 days of her 1918 dry period she was fed 4 pounds of grain C, 4 pounds of legume hay, and 30 pounds of corn silage. Her milk yields in pounds for the first clear month after calving in each of the five years under consideration were as follows:

	pounds
October, 1914	799
September, 1915	731
September, 1916	690
November, 1917	416
January, 1919	873

The milk yield for the first six weeks after calving is not markedly influenced by moderate changes in the contemporaneous food supply (10), and the rations given in the months mentioned above were so nearly equivalent that they could not have produced the observed differences in the milk yield. These are to be attributed, therefore, to the nutritive condition of the cow in her dry periods. The large yield for January, 1919, is the result of the long dry period with a ration considerably above the maintenance requirement.

Cow 201. This animal was a pure bred Holstein, born March 13, 1905, and brought to Beltsville in 1912. The protein and total nutriment contained in her rations during the years 1914, 1915, 1916 and 1917, were calculated and compared with the quantities required for her maintenance and for her milk and fat yield according to the Savage standard, and it was found that she received, on the average, a surplus of about 8 per cent protein and of about 9 per cent total nutriment.

[5] This very low yield is partly explained by the facts that the cow aborted in 1917, and that she had an unusually long dry period in 1918.

She was on pasture for 46 days during the four years under consideration. She calved normally in the autumn of each year. Her dry periods were 50 days on the average.

In 1914, she gave 12182 pounds of milk; in 1915, 8269 pounds; in 1916, 7224 pounds; in 1917, 5708 pounds; and in 1918, 4796 pounds. In 1918, she was given a dry period of 78 days, and, during the last 40 days of this period, was fed a much more liberal ration than during her previous dry periods. She calved October 30, 1918, and her milk yield for 1919 rose to 8711 pounds.

During her dry periods in 1914, 1915, 1916, and 1917, she was fed approximately the same rations as those fed to cow 17 in her corresponding dry periods. During the last 40 days of her 1918 dry period, she was fed daily 11 pounds of grain C, 11 pounds alfalfa hay, and 26 pounds corn silage. Her milk yields in pounds for the first clear month after calving in each of the five years under consideration, were as follows:

	pounds
December, 1914	1138
October, 1915	1230
October, 1916	896
October, 1917	579
December, 1918	1293

For the same reasons as have been given in the case of cow 17, the greatly increased milk yield after the 1918 calving is to be attributed to the more liberal ration fed in the 1918 dry period. It should perhaps be mentioned that this cow was milked three times a day during December, 1918, and only twice in the other months above recorded. But the increase in milk yield to be expected from this change in treatment has been much studied at Beltsville; it could hardly have been more than 10 per cent in such a case as that under consideration. The actual increase as between October, 1917, and December, 1918, was more than 120 per cent.

Experiments showing the effects on milk yield of feeding phosphate with alternated rations during the dry period

The experiments may be briefly described as follows. Cows were dried off about two months before they were due to calve, and were fed, during their dry periods, a basal ration containing 3 to 6 pounds of grain, 4 to 5 pounds of alfalfa hay, and 30 pounds of corn silage. Half of the animals were used as controls and were fed the basal rations

without supplement. The other animals received the same basal rations as the controls, but supplemented with a certain amount of sodium phosphate, and with the grain and hay of the rations fed on alternate days. In many cases the same animal served as a control one year and as an experiment the next year. In a typical experiment an animal would receive daily for 60 days before calving three pounds of grain C (see table 1), 4 pounds of alfalfa hay, and 30 pounds corn silage. The next year, she would receive in the corresponding period the same average daily quantities of the same foods; but instead of receiving equal amounts of all the foods every day, she would receive on one day no grain, 8 pounds of alfalfa hay, and 30 pounds corn silage. The next day she would receive 6 pounds of grain with sodium phosphate added to it, no hay, and 30 pounds of corn silage. For the sake of brevity, the first procedure will be spoken of as the "control feeding;" the second, as the "experimental feeding" or as the "alternated feeding with phosphate."

The animals which received the phosphate were fed alternated rations, as above described, with the idea of separating, to some extent, the calcium and phosphorus compounds in the intestinal tract. There is a good deal of evidence to show that the absorption of phosphorus from the intestinal tract may be hindered by the simultaneous presence of calcium compounds (11). As the hay contains most of the calcium of the rations, and the grain, most of the phosphorus, the experimental animals received an excess of calcium one day and an excess of phosphorus the next. When the average daily ration was 3 pounds grain CP, 4 pounds alfalfa hay, and 30 pounds corn silage, they received about 61 grams Ca and 17 grams P on the days when they were fed hay; and, about 16 grams Ca and 50 grams P on the grain days.

After calving the controls and experiments were fed alike or according to their milk yields. As the milk yield for the first five or six weeks after calving is not much influenced by small changes in the contemporaneous food supply (10), we have not thought it necessary to give a detailed account of how the cows were fed during this period.

The milk and fat yields of the control and experimental animals were followed for the first 40 days after calving, and, as a rule, the milk produced from the tenth to the fortieth day after calving was taken as a measure of the effect of the alternated feeding with phosphate. In many cases the body weights of the animals were followed during the periods when they were on the control or the experimental feeding.

It was decided to use sodium phosphate as the mineral supplement, partly in order to study the effects of phosphorus as distinguished from calcium, partly because the phosphates of sodium are much more soluble in neutral solutions than any of the phophates of calcium, and it was judged that feeding the more soluble salts would produce the maximum effect of the phosphorus on metabolism. Di-sodium phosphate (Na_2HPO_4) was selected, because it is the most nearly neutral of the various sodium salts. A very pure preparation of this compound, containing 9 to 12 molecules of water of crystallization,[6] can be obtained commercially at about $100 per ton.

Sodium phosphate has been fed in only a few of the numerous phosphate feeding experiments which have been carried out in the past. Gouin and Andouard (12) worked with it to some extent, but they give no information in regard to the particular sodium phosphate used or in regard to its water content. If we understand them right, their doses were very small in comparison to those which we finally used. We began with doses of 4.5 grams P as Na_2HPO_4 daily, and finally got up to doses of 24 grams without producing any noticeable digestive disturbances whatever.

In deciding on the basal ration to which the phosphate was to be added we were largely influenced by the fact that the dry cows at Beltsville had previously been fed as a matter of routine, a ration consisting of 4 pounds grain,[7] 4 pounds of legume hay, and 30 pounds of corn silage.

This ration carries decidedly more than enough protein and total nutriment to provide for the maintenance of a 1000 pound cow, according to the Haecker and Savage Standards; (9) and according to the results obtained by Eckles (2), the surplus should be sufficient to provide for the development of the unborn calf. Using a slightly less liberal feed for the basal ration made it possible to compare the performance of the cows fed phosphate in addition with that of the general herd. In several cases, however, a somewhat more liberal ration was used both for the control and for the experimental animals.

[6] The salt crystallizes with 12 molecules of water, but loses a considerable part of its water of crystallization readily on exposure to air. As obtained commercially, therefore, it generally contains less than 12 molecules of water.

[7] The grain mixture fed has been varied from time to time. Those most frequently used were grains B and C. The protein, total nutriment, and mineral content of these are fairly typical for all the other mixtures.

Alfalfa was selected as the hay to be used, partly on account of its high calcium content, and partly because it had been used at Beltsville in the past as often as anything else.

The experiments fall into two general classes: first, those on animals which had been fed for some years previously according to the routine used for the general herd; and, second, those on animals which had been on test, and which, for at least a year preceding our experiments had been fed much more liberally than the general herd. In the first class there are two smaller groups. Group 1 consists of seven experiments where the same animal served in one year as control; and in another, as experiment. Group 2 consists of experiments in which the records of animals on the phosphate feeding were compared with those of other approximately similar animals used as controls.

The data in the case of the animals which had been on test are rather complicated. In our experiments all these animals were dried off 60 days or more before they were due to calve, and were fed during this period on a basal ration of 3 pounds grain D, 5 pounds alfalfa hay, and 30 to 35 pounds corn silage. The controls received this ration fed in the usual way and without any supplement. The others received grain and hay on alternate days and with phosphate added to the grain. It would be possible to compare the experiments directly with the controls in this series, but as the animals are not exactly comparable, and, as the cases are few, we have thought it better to take into account the past records of both controls and experimental animals. We have, therefore, compared the performance of each animal after either control or phosphate feeding with her performance in the preceding year, and determined whether the phosphate or control performances compare more favorably with the preceding performance of the same animal.

For several years before the experiments began, the cows from the general herd, of which the histories are tabulated in tables 2 and 3 were fed approximately according to the Savage standard. They received, on the average, about 0.25 pound protein and 1 pound total nutrient more daily than this standard calls for. The building of the annual calf is not taken account of in this calculation, but the yearly 91 pounds of protein and 365 pounds total nutriment received over and above what the standard calls for should have provided sufficiently for this process, according to Eckles's (2) results.

The manner in which the test cows were fed contrasts strongly with the above picture. During the year that they were on test and actually milking, these animals received a daily average surplus of 1 to 1.5

pounds protein and about 4 pounds total nutriment. For a number of weeks before they calved, they received the enormous daily surplus of about 4 pounds protein and 16 pounds total nutriment. In other words, the ration fed before calving in preparation for the test contained about 6 times as much protein and about 3 times as much total nutriment as is required for maintenance. In the course of a year, taking into account the dry period before going on test, those animals received about 100 per cent more protein and about 50 per cent more total nutriment than is called for by the Savage standard.

It will be noted that the character of the experiments has made it necessary to keep the animals under observation for periods of more than a year, and to use the milk yield as a measure of the results to be studied. In the course of a year, innumerable small things, which are quite beyond experimental control, but which might have some influence on milk yield, necessarily happen to a cow—weather changes and small disturbances in health and appetite may be mentioned as examples of such incidents. To report them, even to the extent to which they have been recorded in our notes, would be quite impracticable on account of the space required. In the following description, therefore, there are given only such features of the histories of the cows as might have an influence on the milk yield of the same general order of magnitude as the differences which have commonly been observed as the result of the phosphate feeding.

The immediately following paragraphs give in detail the manner in which the animals were fed before calving in our experiments, and tables 2, 3, and 4 give such data regarding the experiments as can be conveniently tabulated.

Rations received before calving by animals used in the experiments

Animals from the general herd

Cow 17, 1918. September 25 to October 18, 3 pounds grain C (see table 1), 4 pounds alfalfa hay, 30 pounds corn silage. October 19 to December 11, 4 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 17, 1919–20. November 26, 1919, to February 14, 1920, alternated rations with daily average of $3\frac{1}{4}$ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage. February 15 to March 29, 1920, alternated rations with daily average of $4\frac{1}{4}$ pounds grain CP, 4 pounds alfalfa, hay, 30 pounds corn silage.

Cow 21, 1918. August 28 to November 30 alternated rations with daily average of 6 pounds grain CP_1, 5 pounds alfalfa hay, 30 pounds corn silage.

Cow 49, 1918. October 31 to December 1, 4 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage. December 2 to 25, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 49, 1919–20. December 12, 1919 to January 14, 1920, alternated rations with daily average of $4\frac{1}{4}$ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 50, 1918. October 2 to December 20, alternated rations with daily average of 5 pounds grain CP_1, 4 pounds alfalfa hay, and 30 pounds corn silage. From October 4 to 9, 85 grams $CaCO_3$ were added daily to the silage on the days when hay was fed; from October 10 to December 20, 158 grams.

Cow 50, 1920. April 2 to June 3, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 54, 1917. March 14 to May 14, 3 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 54, 1919. May 8 to June 2, alternated rations with daily average of 3 pounds grain CP_1, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 59, 1917. October 26 to December 26, 3 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 63, 1917–18. December 1, 1917, to February 1, 1918, 3 pounds grain C, 8 pounds corn stover, 30 pounds corn silage.

Cow 63, 1919. February 3 to March 10, alternated rations with daily average of 3 pounds grain CP_1, 4 pounds alfalfa hay, 24 to 30 pounds corn silage. March 11 to 28, 3 pounds grain C, 4 pounds alfalfa hay, 24 pounds corn silage; rations not alternated. March 29 to April 25, same as February 3 to March 10.

Cow 64, 1918–19. December 9, 1918, to January 5, 1919, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage. January 6 to February 6, 1919, 6 pounds grain C, 5 pounds alfalfa hay, 30 pounds corn silage.

Cow 67, 1918. April 1 to 20, alternated rations with daily average of 3 pounds grain CP_2, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 70, 1918–19. October 19, 1918, to January 27, 1919, alternated rations with daily average of 3 pounds grain CP_1, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 71, 1918. September 25 to December 1, 3 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage. December 2 to 11, 5 pounds grain C, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 71, 1919–20. December 20, 1919, to February 20, 1920, alternated rations with daily average of $3\frac{1}{4}$ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage. February 20 to March 1, 1920, alternated rations with daily average of $5\frac{1}{4}$ pounds grain CP, 4 pounds alfalfa hay, 30 pounds corn silage.

Cow 81, 1919. February 24 to April 24, 1919, 3 pounds grain E, 3 pounds alfalfa hay, 30 pounds corn silage, 5.7 grams Ca as $CaCl_2$ daily.

Cow 81, 1920. February 13 to April 6, alternated rations with daily average of $3\frac{1}{4}$ pounds grain CP, 3 pounds alfalfa hay, 30 pounds corn silage.

Cow 213, 1918. January 1 to February 6, 5.6 pounds grain C, 3 pounds soybean hay, 8 pounds corn stover, 25 pounds corn silage.

Cow 214, 1918. March 28 to May 6, alternated rations with daily average of 3 pounds grain CP_2, 4 pounds alfalfa hay, 30 pounds corn silage. May 7 to 15, alternated rations with daily average of 5 pounds grain CP_2, 4 pounds alfalfa hay, 30 pounds corn silage. May 16 to 27, alternated rations with daily average of 5 pounds grain CP_1, 4 pounds alfalfa hay, 30 pounds corn silage.

Animals which had been on test during the year preceding the experiments

For a month or so before they calved previous to the test lactation period these animals were fed daily rations of from 8 to 18 pounds grain F, 10 to 16 pounds alfalfa hay, and 24 to 30 pounds corn silage. The grain mixtures fed contained more protein and ash than either grain C or grain D. The rations supplied a great excess of both protein and total nutriment above the maintenance requirements.

After they had finished their tests, these animals were dried off about two months before they were due to calve. Cows 227, 232 and 240 were selected as controls and were fed 3 pounds grain D, 5 pounds alfalfa hay and 30 pounds corn silage for 60 days before calving. Cows 228, 229, and 248 served as experiments. For 60 days before calving they were fed alternated rations with a daily average of $3\frac{1}{2}$ pounds grain DP, 5 pounds alfalfa hay, and 30 pounds corn silage.

Comment on comparisons of table 2

Cow 17. This animal gave very little more milk after the phosphate feeding than after the control feeding. She had a long dry period in both cases. It seems likely that the long dry period enabled her to

restore any insufficiency of bone material which may have existed at the beginning of the experiment. She had a uterine infection after the experimental feeding, which may have reduced her milk somewhat in the experimental period.

Cow 49. This animal aborted during the period of phosphate feeding 39 days before term. The abortion greatly shortened her dry period on the phosphate feeding and prevented her receiving the more liberal

TABLE 2

Condensed history of animals used in the experiments. Animals from the general herd used both as experiments and controls

NUMBER OF ANIMAL	DATE OF BIRTH	BREED	DATE OF CALVING		DAYS DRY		MILK YIELD*		FAT YIELD*	
			After control feeding	After phosphate feeding	Control period	Phosphate period	After control feeding	After phosphate feeding	After control feeding	After phosphate feeding
							lbs	*lbs.*	*lbs*	*lbs*
17	1909	Grade Jersey	12-11-18	3-29-20	122	122	847	858	33 9	33 5
49	10-22-14	Grade Guernsey	12-25-18	1-14-20	71	36	831	953	40.7	43 8
50	10-25-14	Grade Holstein	6-3-20	12-20-18	73	98	995	972	38 8	38 9
54	1-22-15	Grade Guernsey	5-14-17	6-2-19	First calf	61	669	1027	24 1	34 9
63	10-17-15	Grade Holstein	2-1-18	4-25-19	First calf	103	422	1018	15.5	34.1
71	7-15-16	Grade Guernsey	12-11-18	3-1-20	First calf	60	632	1121	29.1	49 3
81	2-19-17	Grade Guernsey	4-24-19	4-6-20	First calf	44	685	936	26 0	42.1

* The figures given in these columns represent the number of pounds of milk and fat given from the 10th to the 40th day after calving, except in the case of Cow 54. In this case it was necessary to take the figures for the yields from the 18th to the 48th day after calving, as the daily milk records from the 10th to the 17th day in 1917 had been lost.

grain ration which she had eaten for 23 days before calving during the control period. In the general herd, abortions 5 weeks or more before term have decreased the milk yield from 30 to 50 per cent. We have no way of accounting for the increased milk which was given in this case after the abortion, except as the result of the phosphate feeding.

Cow 50. This animal was fed a much more liberal grain ration than the others in both the control and experimental periods. She "leaked"

milk from her udder to a considerable extent through the experimental period, and she had a uterine infection after calving in the control period, which may have somewhat reduced her milk yield. She gave a little more milk in the control period than in the experimental period. The numerous disturbing circumstances make it difficult to interpret the results, but they seem to us to indicate that the addition of phosphate will often have little effect when the basal grain ration is as high as 5 pounds daily.

Cow 54. This cow aborted during the phosphate feeding 28 days before term. Judging from the history of such cases in the general herd, her milk yield should have been about 10 per cent less than after the control feeding. We have no way of accounting for the actual increase except as the result of the phosphate feeding.

Cows 63, 71, and 81. The remaining three animals of table 2 were fed on the control rations before their first calves were born and on the experimental rations before their second calves were born. It is well known that heifers are likely to give more milk with their second than with their first calves, the average increase has been worked out by Pearl and Patterson (7) for Jerseys, and we have in the Department figures obtained from the cow-testing associations for Guernseys and Holsteins. In table 9 we have given the actual and expected increases; in calculating the expected increases, we have in each case used the set of figures which would give the largest increases, in order to avoid any possible suspicion of favoring the results of the phosphate feeding. The milk yield of all three heifers increased after the phosphate feeding decidedly more than would be expected as the result of age alone. We have no way of accounting for the additional increases, except as the result of the phosphate feeding.

Comment on comparisons of table 3

The animals of which the histories are here tabulated were used in early experiments, in which we were still feeling around for the conditions under which the effects of the phosphate feeding would stand out most sharply, and in which the treatment of the subjects was not so carefully controlled as in the later experiments. The results, however, are in general accord with those of the later experiments, and it has seemed to us worth while to report them.

It would, perhaps, be fair to compare cow 59 with cows 67 and 70; cow 64 with cow 21; and cow 213 with cow 214. The figures for cow

59 represent approximately the average performance for the heifers of the general herd with their first calves. Cow 67 is a half sister of cow 59. The two animals have the same sire; the dam of 67 has a somewhat better record than that of 59. Cow 70 was selected in order to try the effects of phosphate feeding in an unfavorable case. Her mother had the poorest record of any cow in the herd except two, and she herself was of unpromising appearance. Cow 64 was milked only

TABLE 3

Condensed history of animals used in the experiments. Animals from the general herd used only either as experiment or control

NUMBER OF ANIMAL	DATE OF BIRTH	BREED	DATE OF CALVING	DAYS DRY	MILK YIELD*	FAT YIELD*
			Controls			
					lbs.	lbs.
59	8-10-15	Grade Holstein	12-26-17	First calf	568	20 5
64	10-18-15	Grade Holstein	2-6-19	62	1108	40 1
213	9-26-15	Holstein	2-6-18	First calf	742	26 7
			Experiments			
21	1907	Grade Jersey	11-30-18	85	1458	60 9
67	12-29-15	Grade Holstein	4-20-18	First calf	753	26 3
70	4-22-16	Grade Guernsey	1-27-19	First calf	588	28 3
214	3-18-16	Holstein	5-27-18	First calf	1554	46.8

* The figures given in these columns represent the number of pounds of milk or fat given from the 10th to the 40th day after calving.

twice a day; and cow 21, three times. The difference in the milk yields is, however, larger than is generally produced by this difference in treatment. Cows 213 and 214 were half sisters, both being daughters of the same sire. The dam of cow 213 had a decidedly better record than that of cow 214. Cow 213 was milked only twice a day; and cow 214 three times, but the difference in milk yields is very much greater than could be accounted for by this difference in treatment.

Comment on comparisons of table 4

We do not think it necessary to make any detailed comment on the results given in table 4.

The differences in milk yield as between the cows fed phosphate and those fed the basal ration alone are so small as to be insignificant.

TABLE 4

Condensed history of animals used in the experiments. Animals which had been on test during the year preceding the periods of control and phosphate feeding

NUMBER OF ANIMAL	DATE OF BIRTH	BREED	DATE OF CALVING		DAYS DRY		MILK YIELD*		FAT YIELD*	
			Test period	After control or phosphate feeding	Before test period	Control or phosphate feeding period	Test period	After control or phosphate period	Test period	After control or phosphate feeding period
Controls										
							lbs.	lbs.	lbs.	lbs.
227	8-2-15	Holstein	4-18-18	1-11-20	First calf	137	1674	2019	61.8	83.8
232	3-31-16	Holstein	11-29-18	3-15-20	First calf	58	1591	2046	45.5	67.5
240	11-10-14	Holstein	9-27-18	2-9-20	59	112	1876	1881	64.2	80.9
Experiments										
228	9-2-15	Holstein	4-4-18	12-30-19	First calf	79	1429	2016	44.7	64.9
229	11-8-15	Holstein	5-28-18	1-31-20	First calf	94	1817	2078	53.8	71.7
248	3-15-16	Holstein	1-22-19	6-17-20	First calf	63	1594	1611	51.0	45.1

* The figures in these columns represent the milk and fat yields from the 10th to the 40th day after calving except in the case of Cow 229. In her case they represent the milk and fat yields from the 20th to the 35th day after calving multiplied by 2. It was necessary to take these figures instead of the usual ones, as she was sick for some days after calving in 1920, and suffered a severe cut in her rations, and got sick again on the 36th day after calving.

It follows that the favorable influence of the phosphate feeding is reduced to negligible proportions in the case of cows which have been super-abundantly fed in their immediately preceding lactation period.

Effects of phosphate feeding on body weight

Both the animals on the experimental feeding and those used as controls were weighed from time to time. The results are given in tables 5, 6, 7 and 8. These figures summarize all the pertinent results that we

TABLE 5

Body-weights of animals on control and phosphate rations. Heifers on control rations; all four pregnant

NUMBER OF ANIMAL	PERIOD DURING WHICH WEIGHINGS WERE TAKEN	AVERAGE DAILY GAIN	DAILY RATION		
	days	*lbs*	*lbs.*	*lbs.*	*lbs.*
67	20	1 75	Grain C..... 3	Alfalfa hay.. 4	Corn silage.. 30
71	60	0 65	Grain C .. 3	Alfalfa hay.. 4	Corn silage.. 30
81	180	1 04	Grain E.. .. 3	Alfalfa hay.. 3	Corn silage.. 30
214	59	0.90	Grain C ... 3	Alfalfa hay.. 4	Corn silage.. 25

TABLE 6

Body-weights of animals on control and phosphate rations. Heifers fed alternated rations with phosphate; no. 70 pregnant, no. 74 farrow

NUMBER OF ANIMAL	PERIOD DURING WHICH WEIGHINGS WERE TAKEN	AVERAGE DAILY GAIN	AVERAGE DAILY RATION		
	days	*lbs.*	*lbs.*	*lbs.*	*lbs.*
70	70	1 24	Grain CP_1 . . 3	Alfalfa hay.. 4	Corn silage.. 30
74	80	2 20	Grain CP_1 . 3	Alfalfa hay.. 4	Corn silage.. 30

TABLE 7

Body-weights of animals on control and phosphate rations. Cows fed control rations during dry periods before calving

NUMBER OF ANIMAL	PERIOD DURING WHICH WEIGHINGS WERE TAKEN	AVERAGE DAILY GAIN	DAILY RATION		
	days	*lbs.*	*lbs.*	*lbs*	*lbs.*
17	50	1.38	Grain C..... 4	Alfalfa hay.. 4	Corn silage.. 30
50	59	1 76	Grain C..... 5	Alfalfa hay.. 4	Corn silage.. 30
51	47	1 28	Grain C..... 3	Alfalfa hay.. 4	Corn silage.. 30
64	60	1.32	Grain C 6	Alfalfa hay.. 5	Corn silage.. 30

have. Heifers 67 and 214 were fed on the control rations in the late winter of 1917–1918 and changed over to the experimental rations a few weeks before they calved. They, therefore, figure as controls in table 5 and as experiments in table 3. They were on the experimental

feeding for such short periods that the weights obtained from them during those periods can not be used in the present discussion.

It seems worth while to give in more detail the histories of two animals of which the weight changes on the experimental feeding were followed for comparatively long periods.

TABLE 8

Body-weights of animals on control and phosphate rations. Cows fed alternated rations with phosphate during dry periods before calving

NUMBER OF ANIMAL	PERIOD DURING WHICH WEIGHINGS WERE TAKEN	AVERAGE DAILY GAIN	AVERAGE DAILY RATION		
	days	*lbs.*	*lbs.*	*lbs.*	*lbs*
17	52	0.93	Grain CP.. $4\frac{1}{4}$	Alfalfa hay.. 4	Corn silage.. 30
21	80	1 57	Grain CP_1. 6	Alfalfa hay.. 5	Corn silage.. 30
50	30	2 50	Grain CP_1.. 5	Alfalfa hay. 4	Corn silage.. 30
71	30	1 87	Grain CP.. 3	Alfalfa hay.. 4	Corn silage.. 30
81	31	1 03	Grain CP... 3	Alfalfa hay.. 3	Corn silage.. 30

Heifer 74 was born October 15, 1916. From October 19, 1918 to January 15, 1919, she was fed alternated rations with phosphate, receiving as a daily average 3 pounds grain CP_1, 4 pounds alfalfa hay and 30 pounds corn silage. She was still farrow during this period. Her weights were as follows:

	pounds
October 24	754
November 23	804
December 23	890
January 12	930

Cow 21 was born in 1907. From August 28 to November 30, 1918, she was fed alternated rations with phosphate, receiving as a daily average 6 pounds grain CP_1, 5 pounds alfalfa hay, 30 pounds corn silage. She had calved previously, November 7, 1917, and became dry September 6, 1918. She calved again November 30, 1918. During the period of phosphate feeding, her weights were as follows:

	pounds
September 2	1027
October 2	1107
November 1	1143
November 21	1153

Her best previous month's record for milk yield on the Beltsville farm was made in October, 1914, and amounted to 1041 pounds. After this, her milk yield gradually fell off; the best month's production after the 1917 calving was 469 pounds. She was in very good condition when she calved in 1918: in December, 1918, she produced 1276 pounds of milk; and in January, 1919, 1315 pounds.

These two cases show clearly that sodium phosphate may be fed to cows for long periods in large amounts without producing any deleterious effects on the digestive and assimilative processes.

TABLE 9

Basis for an attempt to estimate how much the alternated feeding with phosphate increased the milk yield in the cows of the general herd under the conditions of our experiments. The column headed "Expected yield after alternated rations with phosphate" gives the milk yields to be expected after the experimental feeding, using the yields after the control feeding as a basis, and taking into account the facts that the animals were generally older during the experimental feeding and that some of them aborted. The figures represent pounds of milk yielded in 30 days beginning soon after calving

NUMBER OF ANIMAL	ACTUAL MILK YIELD AFTER CONTROL RATIONS	EXPECTED MILK YIELD AFTER ALTERNATED RATIONS WITH PHOSPHATE	ACTUAL MILK YIELD AFTER ALTERNATED RATIONS WITH PHOSPHATE
	lbs	*lbs.*	*lbs*
17	847	847	858
49	831	565	953
50	995	995	972
54	669	599	1027
63	422	495	1018
71	632	739	1121
81	685	753	936
Totals...........	5081	4993	6885

The actual yields after the alternated feeding with phosphate average 37.9 per cent more than the expected.

Account of unsuccessful and incomplete experiments

Many experiments on the effects of phosphate feeding were begun and then had to be abandoned because the animals aborted or failed to calve, or for other reasons. In other cases phosphate was fed to certain animals, but under rather different circumstances from those in the experiments which have been reported. We wish to speak briefly of these unsuccessful and incomplete experiments partly because the re-

sults sometimes furnished interesting hints, partly in order to avoid any suspicion that the results reported for the successful experiments might be cases unconsciously selected in which the milk yield happened to be large after the phosphate feeding.

Several animals were started on the control rations, and then either aborted or turned out to be sterile. It is not necessary to say anything about these, further than that, in the cases where they aborted, the milk yields were such as would be expected from a consideration of their histories in comparison with those of the rest of the general herd.

Cow 63, the histories of whose 1918 and 1919 lactation periods have already been given in detail, was started again on the basal rations in 1920. She carried her calf to term, but acquired an acute general infection after she had been milking about two weeks, which rapidly reduced her milk yield to a very low point, and finally made it necessary to have her slaughtered. She began this lactation period, however, with a milk yield which promised to be as good as or better than that of 1919 after the phosphate period. It is to be remembered that her dry period in 1919 on the phosphate feeding was 103 days; and her dry period in 1920 was also about 100 days. We are inclined to think that these long dry periods made it possible for her to store up a good quantity of calcium and phosphorus, and it would not be surprising if the effect of the long dry period with phosphate feeding in 1919 lasted over into 1920.

Several cows started on the phosphate feeding turned out to be sterile; and one aborted, in addition to Cows 49 and 54, whose histories have already been reported in detail. The abortion in question occurred at a period when it was the custom to remove aborting cows from the farm immediately, and before we realized that cows which aborted after a period on the phosphate feeding might give more milk than they ever had before. We have no knowledge of the amount of her milk yield after the abortion.

Besides the cases so far reported, there are only seven animals which have received any sodium phosphate at all. One of these received small daily doses (6.9 grams P as sodium phosphate) from the time she was born up to when she threw her first calf. She aborted with this calf, and gave a rather small quantity of milk subsequently. On account of the abortion and of the fact that the doses of phosphate were small, we do not think that this experiment throws any light at all on the question of the effects of phosphate feeding on the subsequent milk yield.

The other six animals received basal rations alone, and then the same rations with phosphate added, for short alternated periods, the

main purpose of the experiments being to determine the effects of feeding phosphate on the concentration of phosphorus in the blood. Three of these happened to abort after periods of a week or more on rations without phosphate. They gave about the quantities of milk which would have been expected on the supposition that they had never had phosphate.

The other three threw their calves while on the phosphate feeding. Two of them aborted after seven and ten days of phosphate feeding respectively. Both gave more milk than they ever had before, and decidedly more than would have been expected on the supposition that they had never had phosphate. The third was a heifer carrying her first calf. She calved normally at term after 26 days of phosphate feeding and gave much more milk than the general average for the herd with their first calves. These last three results suggest that even a short period of phosphate feeding may have a markedly favorable effect on milk yield if it occurs during the few days immediately before calving, during which the udder is rapidly enlarging in preparation for the coming lactation period.

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OFFICIAL GRADING AND CONTROL OF DAIRY PRODUCE FOR EXPORT

J. A. RUDDICK

Dominion Dairy Commissioner, Ottawa, Ontario

In bringing this subject before the convention I wish to state at the outset that while I personally believe in the principle of grading dairy produce and other commodities for export, I am not here at the moment to advocate the adoption of such a system in connection with the export of our butter and cheese, or to urge it upon the dairymen of Ontario at the present.

Some months ago, at a conference with the provincial deputy ministers of agriculture, the subject was discussed, and it was agreed that the grading of dairy produce for domestic trade or for educational purposes might be considered a provincial function, but that grading for export was essentially a dominion function. During the last session of Parliament a resolution calling upon the government to establish a grading system for export dairy produce was introduced in the House of Commons. It received unanimous support from the members. The minister of agriculture in his reply accepted the principle of the resolution, and stated that when the producers were ready to have their butter and cheese graded the Dairy Branch would be prepared to carry out such a scheme. While the attitude of the House on this question might almost be taken as a mandate, the reply of the minister gives you the policy of the department in the matter. In other words, when you intimate that you are desirous of having such a service performed, means will be found to carry it out, but it is not the intention of the minister to force it upon the country. In the meantime we feel that while this matter is being discussed and receiving some attention from all progresive dairymen, that it is our duty to collect and disseminate as much information on the subject as possible.

The grading of produce is not a new idea, and it is over twenty years since it was first applied to butter and cheese. As a mat-

ter of fact the principle of grading has always been recognized in the Canadian cheese and butter trade. In selling your cheese the price is usually fixed on the basis of no. 1 quality. On delivery the buyer inspects the shipment and decides whether the quality is up to the standard of no. 1 quality or should be rated lower. Thus you have a rather crude attempt at grading, but its great weakness is that the grader is an interested party, to whom it is an advantage to have the grade reduced as low as possible. Such a one-sided system breeds suspicion and leads to discontent. The wonder is that there has not been greater dissatisfaction than there is. It speaks well for the character of the buyers of cheese that such a loose method should have prevailed for so many years.

Then the question before us is not so much the introduction of grading as something new, as it is the substitution of an organized system carried out by disinterested parties with a legal status and based on clear-cut definitions, for the present one-sided and haphazard arrangement. In other words whether the quality of every lot of cheese shall be determined accurately and the price fixed according to value, or that the matter shall be left entirely in the hands of one party to the transaction, who may be influenced by market conditions and other considerations.

Official or government grading of dairy produce has been in force in different countries for a good many years, and we now have in Canada a number of grading services in operation. It may be worth while at this stage to state very briefly how these different services are carried on and the particular object that was in view when they were organized.

Let us begin with New Zealand, because that country was the first to adopt government grading of dairy produce—about twenty-five years ago—and because it is the only country in the world from which no dairy produce may be exported unless it is graded. The grading of butter was started in New Zealand as an educational measure, and to give information to the buttermakers as to the quality and character of the butter which they were turning out. When this matter was first taken up there were no regular exporters in that country. The export butter

and cheese were mostly handled by wholesale importing firms who bought New Zealand produce or secured the shipping of it in order to help out their exchange. There was no examination or inspection of the butter or cheese at the time of shipment. It was usually consigned to some importer in London. It was from three to six months old before it reached its destination and then another month or two would elapse before definite reports on the quality came back to the maker. It was this state of affairs that induced the government to inaugurate a system of examination, largely for the purpose of giving information and guidance to the makers.

The application of a complete grading system in New Zealand was comparatively simple compared to what it would be in Canada, and I need only describe briefly the geographical situation and other conditions to make this quite clear. In the first place New Zealand is a small, compact and insular country. Export is possible by steamer only. All the towns and shipping centers are at the seaboard, and the cold storage warehouses where the butter and cheese are stored are located on the docks so that vessels are loaded direct from the warehouses. Home consumption is relatively small and the bulk of cheese and butter produced is exported. The result is that the great majority of factories make butter and cheese for export only, and when it is shipped from the factory to the cold storage warehouse there is never any doubt as to whether it is to be exported or held for local trade. The local trade is taken care of by certain factories which do not go into the export trade as a rule. The grading of dairy produce in New Zealand is carried out under the dairy produce act and regulations thereunder. The butter or cheese, as the case may be, must be shipped regularly to certain specified cold storage warehouses. All export butter and cheese must go through these warehouses. The regulations require that the churning number shall be marked on each box of butter and the vat number on each box of cheese, so that the grader may select one package from each churning or vat in the shipment and score the whole as one lot. The grading is done as the butter or cheese is being transferred from the railway cars or trucks to the govern-

ment cold store. When the grade has been determined one or other of the grade marks, "1," "2," or "3," as the case may be, are placed on each package in the shipment. After grading and marking, the butter and cheese are wholly under the control of the government officer in charge of the grading station, and the owner has no access to them. He gives his instructions as to when and to whom they should be shipped and the manager of the warehouse attends to the shipping details. There is no such thing in New Zealand as a "through" bill of lading issued at interior points. Then again, none of the exporters have warehouses of their own. They couldn't use them if they had, for everything must go to the government grading store. In New Zealand the export trade was developed under the grading system, and therefore fits into it, while our export trade has been free to develop without restrictions of any kind, and has got into channels which are now well worn and certain customs are rather firmly established. Another essential difference in the export trade of the two countries is that in New Zealand the disposal of the year's output is usually arranged for at the opening of the season, and prompt and regular shipment is the rule. Indeed the regulations, while they require that butter must be in store for three days after grading, also require that it shall be shipped out by the first available steamer thereafter. I need not point out how this practice differs from our own.

Designed at first as a purely educational scheme, as time went on the commercial value of the New Zealand grader's certificate became more and more recognized, until today it is of first importance. Sales are now based almost wholly on the grades, of which the grader's certificate is visible and accepted evidence.

In Australia a similar system is in force under state authority, and varies somewhat in the several states which have made any attempt at grading.

I have pointed out the difference between New Zealand and Canada in regard to the export trade in dairy produce that the difficulties of setting up such a system in this country may be appreciated, and to show that some "give and take" will be necessary before it is, if ever, an accomplished fact.

In South Africa they have a law which provides for the grading of all kinds of produce, which may be applied in different localities by Order-in-Council. All the cheeses are now graded which are shipped from one dairying district. The manufacture of cheese and butter has not yet reached large proportions in South Africa, the net export of cheese in 1918 being only 191,085 pounds.

In the United States, under the Food Products Inspection Law, the federal dairy division has appointed inspectors, who are located at Boston, New York, Philadelphia, Chicago, and Minneapolis. These inspectors are prepared to grade butter on application of anyone having a financial interest in the shipment, but they do not undertake any inspection or grading of their own volition. This comes under the head, therefore, of voluntary or optional grading. It is confined to the five cities which I have mentioned. There are some interesting points in connection with the United States inspection service, and if anyone wishes to obtain more particulars I would suggest that he write to the Bureau of Markets, Department of Agriculture, Washington, and ask for Service and Regulatory Announcement No. 51.

In Canada we already have some grading carried on under both federal and provincial and other authorities. It is both official and unofficial. In some cases it is carried out for educational purposes, while in others the object is purely commercial, but all the grading being done in Canada at the present time is more or less voluntary and has no authority of law behind it.

I think it is only fair to say that the first grading of butter in Canada was carried out in Alberta. The sample system is followed, and it is not compulsory, although practically all the creameries in the province avail themselves of the service. No Alberta creamery can sell its butter to advantage in the British Columbia market unless it is covered by the Alberta grader's certificate, as some of the creameries have learned to their cost when they have attempted to act independently of the grading system.

The grading of butter is also carried out in both Saskatchewan and Manitoba along the same lines as those followed in Alberta,

and it may be said now that the great bulk of all the creamery butter produced in the prairie provinces is graded by the different provincial authorities. There is no doubt that the grading of butter has been an important factor in winning for the butter of the prairie provinces the strong position which it holds today.

The Dairy Branch of the Provincial Department of Agriculture at Toronto has, as most of you know, been conducting a voluntary or optional butter grading service on the sample plan for the last three years.

The Quebec Agricultural Coöperative Society has been grading cheese and butter in bulk for sale by auction in Montreal for some years past. The Society practically does its own grading although it has the backing of the Provincial Department of Agriculture.

The Montreal Produce Merchants' Association employs an inspector who passes judgment on the quality of butter and cheese in transactions in which the members of the Association are interested. This is the only instance of purely unofficial grading being carried on in Canada at the present time.

The Dairy Branch at Ottawa has undertaken to grade the cheeses which are to be sold by auction by the United Dairymen Coöperative at Montreal. A certificate is issued in duplicate, one copy going to the purchaser and one copy to the Manager of the Coöperative Society, who passes it on to the factory. The grading at Montreal is on a purely commercial basis, although it is possible to use the information for educational purposes by passing it on to the instructors.

In the province of New Brunswick during the past two years practically all the cheese manufactured has been graded for the local market by an official of the Provincial Department of Agriculture. The dealers agreed to purchase only graded cheese and to scale the price as between first, second and third grades. The quality of New Brunswick cheese has shown marked improvement under this stimulus and relatively a much better price has been obtained for it.

During the years 1917 and 1918, when the cheese was handled by the Cheese Commission and the Dairy Produce Commission,

every box exported was to all intents and purposes classified into no. 1, no. 2, or "off grades," according to the now generally adopted Canadian standards and definitions. The cheeses were classified by the dealers who offered them to the Commission, but the Commission inspected every lot to see that the classification was according to quality, and a definite spread of one-half cent per pound was made in the price as between first and second grades.

Thus you see, from the foregoing statements, that a considerable amount of grading is being done in Canada at the present time, according to different plans and under different auspices and having different objects in view. It would be, however, a very long step from the present voluntary or optional grading service which is carried out here and there, to a complete or general and compulsory service for the grading of all dairy produce to be exported. There are, however, no insuperable difficulties in the way. It is quite possible that it might be found desirable to apply it with certain limitations. For instance, it would be a comparatively simple requirement to say that only the cheese and butter exported through the port of Montreal to the United Kingdom should be graded. That would be very different to requiring that all dairy produce for export should pass through that port to be graded. Occasional shipments of butter or cheese to the United States, to the West Indies, or other places, not passing through Montreal at all, might be exempted from the provisions of any regulations governing the grading of dairy produce. These are matters that would all have to be considered before any definite decision could be reached. The main thing for us to consider at the present time is what are the advantages or disadvantages that might be expected to arise from the adoption of a grading system.

Having been responsible for the reorganization of the grading service in New Zealand while I was dairy commissioner in that country, I have naturally watched the working out of the policy with very much interest. It is as clear to me as it can be that the grading system has been of immense value to the New Zealand dairying industry. As an educational measure it has been a

strong factor in raising the standard of quality. The confidence established in the British market and the simplification of trading has tended to popularize New Zealand produce in the old country, and don't forget that popularity does not rest solely on the matter of quality. Although quality is of first importance, standardization, confidence and elimination of disputes over quality, all of which grading promotes, go a long way in building up a reputation for any article.

It is worthy of note that in 1917 the percentage of no. 2 cheese received by the Cheese Commission was 15.13 per cent of the whole. In 1918 the percentage of no. 2 cheese was only 11.16 per cent, and it is a fair assumption that a considerable amount of credit for this improvement should be given to the grading of the cheese.

Some very interesting results have followed the grading of the cheeses which were sold by auction at Montreal during the past season by the United Dairymen Coöperative. Let me give you one instance. The cheeses from a certain factory were all graded no. 2 for the first four sales; after that they were never lower than no. 1, three lots were graded "special," and one lot made the record high score for colored cheese. Can anyone doubt the value of grading to that factory? Under the present system it is not always brought home to the factory as it should be when there is any falling off in the standard of quality. Very often, owing to market conditions and for other reasons, no fault is found with the quality, although it may be only a second grade. While there may be a temporary gain to the factory which sells a no. 2 article for a no. 1 price the result is very bad in the end as it engenders a false sense of security and tends to perpetuate the errors. It is in the interest of the factory in the long run that it should be advised, regardless of market or any other condition, as to the exact quality of its product.

As for the disadvantages attending the adoption of a grading system, I do not see that there are any. It will fit in with the present methods of selling cheese either coöperatively by auction, or on the cheese boards. No expense will be added to the handling of either cheese or butter, nor will the business of anyone connected with the trade be necessarily disturbed.

It will be necessary to have some legislation and regulations to govern the carrying out of such an important line of work. As far as the factories are concerned no obligations will be imposed, nor will they be required to do anything which they are not doing now, except possibly to mark the number of the vat or the number of the churning on each package. I cannot understand why they do not do that now, without any compulsion. I could point out case after case where factories have lost much money through their failure to observe this very simple requirement.

We come now to the second part of my subject, namely, that of government control of exports.

I have seen it stated that the butter exported from Denmark is graded, but this is not the fact. There is, however, a very important system of control over the export of butter not only in Denmark but in Sweden and Holland, and it may be interesting to describe these systems at this point, because the results commercially are similar, in some respects, to those which follow a system of grading.

No butter of Danish origin may be exported from that country which does not bear the national or "Lur" brand. This brand may not be used on any butter shipped out of the country but manufactured elsewhere, and no creamery is permitted to use it unless the butter comes up to a certain standard of quality. Nominally the government administers these regulations, but in reality it is the creameries themselves that have taken the initiative in this as in other matters, and in effect the Union of Danish Creamery Associations say to the dishonest, careless, or inefficient creamery, "We will not allow you to export your inferior butter and thus injure the general reputation of Danish butter and prevent those of us who produce a first-class article from getting the maximum price for it."

The national or "Rune" brand of Sweden is applied in much the same way as the Danish national brand, and for the same reasons.

In Holland a slightly different system of control prevails. Holland is a great dairying country, in some respects the greatest in the world. For intensive production, for thoroughness of

organization, and for superiority of buildings and equipment it excels any other country that I know. But Dutch butter at one time acquired a rather bad reputation for adulteration, and it lost popularity in the British market on that account. Dutch butter sold from 3 to 4 cents per pound below that of Danish, although the quality of much of it was undoubtedly just as good. That was the result of lack of confidence. The Dutch government, therefore, took the matter in hand and established a system of control under which frequent examinations are made of the butter of any creamery that desires to come under the system, and when the authorities are satisfied that the creamery in question is turning out a pure article of good quality they are allowed to use the government control mark, which consists of a very thin piece of paper printed with certain wording and so cut or scored that when it is once pressed on the surface of the butter it seems to be impossible to remove it without tearing it all to pieces. These paper marks are supplied by the government, and each bears a number for the purpose of identification.

These systems of control serve to some extent the same purpose as that of grading, except that there is no certificate issued which can be used as a commercial document. They are more applicable, it seems to me, to countries in which the bulk of the produce has reached a high level of quality and is generally uniform throughout. The control system is not of the same educational value to the butter-maker or to the creamery or cheese factory as a system of grading is.

Returning to the matter of grading, I need hardly point out that it may take a good many different forms and be applied in various ways and with different objects in view. Thus it may be educational in its object, or it may be purely commercial, or a combination of both; it may be compulsory or merely optional or voluntary; it may be confined to either the export or home trade, or it may cover both wholly or in part; it may be official through a government department, or unofficial as where the grader receives his authority from a voluntary organization. In a country like Canada it may be carried out under either federal or provincial auspices; and finally, the grading may be done on

samples or in bulk. So when we talk about a grading system, it is well to know just what we have in mind.

My final point is that as our principal competitors in the British market have adopted some measure of grading or other control over exports, it would seem to be the part of wisdom for us to give the matter careful consideration, with due regard to the difference in our conditions as compared with these other countries. With grading in New Zealand, Australia, and South Africa, with regulation of exports by which dairy produce of inferior quality is not allowed to leave Denmark and Sweden, and with Holland guaranteeing the quality of butter and cheese bearing the government mark, we are not going to have things all our own way.

Personally, I have not in the past been a very enthusiastic advocate for the adoption of a general system of grading, because I did not believe that this country was ready for it, but I will go farther than I did in opening and say that I believe now that the time has come when if we are to hold our own under the keen competition, keener than it has ever been before, we must take advantage of every means of placing our surplus of dairy produce on the world's markets under the most favorable conditions possible. A system of grading for export dairy produce, if adopted, would have in this country a threefold object. First, it would be educational; second, it would facilitate trading and promote confidence in our produce; third, it would give the maker of the high grade article full recognition and reward.

It would be educational because the grader's reports or certificates on low grade produce would show the maker wherein his produce was defective. Without such information he must rely on the opinions and reports of the buyers, and with all due respect to these gentlemen, I do not hesitate to say that very frequently opinions expressed by them are misleading, because in some cases they have not the necessary practical knowledge, and it is not always in the interest of the buyer to find fault with the quality of his purchase. I repeat that, generally speaking, there are few complaints as to quality and no reduction in price when the market rises, and thus the maker is misled and repeats his errors.

When complaints are made on a falling market the maker does not believe in the fairness of the claim and attributes it wholly to a question of market conditions. A grading system would eliminate these misunderstandings and disputes over quality. The maker of high grade butter or cheese does not, under the present system, receive his just reward. There is a tendency to fix the price on the average quality, as the buyer does not care to incur the onus of criticizing or rejecting. He would rather pay one price and then clear himself by taking losses on part of it if necessary and making a larger profit on the goods of higher quality. No fault can be found with anyone on this score because it is the natural outcome of our present method of doing business.

In conclusion let me say this, that no one has a higher appreciation of the outstanding position which Canadian cheese has reached in the world's market than I have. It is the largest item in the international trade, and in the matter of quality it stands absolutely at the top. We have reached this position without any system of grading but it must be remembered that while we were making our reputation no other country had such a system. Our position as the largest exporter of cheese in the world is being threatened to some extent by New Zealand, but I am of the opinion that it will be many years before New Zealand exports as much cheese as Canada does. At the present moment there is a tendency to swing back to butter-making in New Zealand. Our production of cheese has been reduced to some extent in recent years by the great extension of the condensed milk and milk powder industry. The recent check to the condensed milk industry would indicate that the cheese industry has nothing to fear from that source in the near future. We cannot, however, continue to hold our position in the cheese trade unless we are prepared to meet our competitors on equal footing, and the development of the grading idea all over the world is something which we cannot afford to ignore.

With regard to butter, our position is very much weaker. The surplus for export is comparatively small. It will probably be in the neighborhood of 16,000,000 pounds for the season of

1920. The quantity is irregular, and our reputation suffers from the fact that a great deal of the butter is held during the summer months for speculative purposes. There is every indication, however, that our exports of butter will show very considerable increase in future years, and if it is to win as favorable a position as our cheese has we must do everything in our power to meet a competition which is even keener in the case of butter than it is in that of cheese.

I have endeavored to put the facts of the situation before you as clearly as possible in order that you may understand it and act accordingly.

WHAT IS A FAIR STANDARD FOR ICE CREAM?

R. M. WASHBURN

Director of Laboratories International Dry Milk Company, Minneapolis, Minnesota

Ice cream is very distinctively an American product, even though it was known in some form for several hundred years in Europe before it was introduced to this country. In Europe and during times past it bore slight resemblance to the mellow creamy uniform article of the present. Then, too, our people were the first to develop the wholesale manufacture of ice cream, to introduce ice cream parlors and in general to develop the ice cream habit. Before the world's disturbance ice cream might have been had in sea port towns in nearly every part of the world and on most ocean liners, and yet it was the American made product, taken chiefly from New York City. In other parts of the world ice cream is a kitchen product made where served, and varies in quality accordingly.

AS A CONFECTION

Ice cream, until very recently, was classed as a confection along with candy and soft drinks and as such came close to being ruled out of business at the time of the greatest shortage of sugar, and it was fortunate indeed that food officials counseled with the ice cream manufacturers and others regarding the product, for then it was pointed out that, being made of cream, condensed milk and sugar chiefly, it possessed very definite food values.

AS A FOOD

Critical analysis of ice cream revealed the fact that it possessed much of the same food properties as butter or cheese, which are made from the same general source, though naturally differing in its nutritive relation. In the past, ice cream (so-called) has been made from probably thousands of combinations of milk, cream, eggs, sugar and condensed milk, so that when the article first entered commerce it varied greatly in its value, and after

growing to considerable proportions seemed to demand a standard especially as to fat content. This was done to guarantee to the consumer that a proper amount of food nutriment might be obtained with a given purchase. The question was what the standard should be. One group of workers advised that the fat standard of ice cream should bear a definite relation to the fat standard in cream which was legal in the community in which the ice cream was made. This, however, seemed illogical to a few workers who believed that the fat content of ice cream should be governed by the product and its uses, rather than by the raw material from which it was made.

BASED ON CREAM

The first fat standard for cream to gain general recognition was that advocated by the national pure food law which fixed 18 per cent fat as the minimum. Using this as a basis and reasoning that since the introduction of sugar into the cream in sufficient amount to make it palatably sweet, would dilute or reduce the fat content to nearly 14 per cent; that 14 per cent should therefore be considered as the legal minimum of fat for ice cream.

It is now generally recognized and recently sustained that the various states have the right to establish and enforce standards in food commodities. It is likewise established that cities of the first class have this right where such does not conflict with the state. Therefore, the fat standard of ice cream would become as variable as the cream standards in the several states and cities if ice cream were to be based upon cream. For instance, the legal standard of cream in Minnesota is 20 per cent, Wisconsin 18, and Iowa 16. Consequently the ice cream fat content should be about 17, 15 and 13, respectively. Consequently if a manufacturer located at, say Winona, La Crosse, or Decorah, shipped into three states named, he would either have to make three grades, keep them separate in his storehouse and in the shipping, which would be next to impossible, or he would have to put into all his cream enough fat to meet the highest requirement and be

very much handicapped in meeting the competition in the states requiring less fat. As between cities, we notice that 20 per cent fat in cream is demanded in Los Angeles, Portland, Spokane, Memphis, Minneapolis, and Washington, D. C., while 18 per cent suffices to satisfy Toledo, Syracuse, Seattle, Philadelphia, and New York, and 16 per cent is enough for Newark, N. J., Columbia, S. C., and Denver, Colo., but again we note that the ordinances of Chicago, St. Louis and Boston require but 15 per cent fat, with Beaumont, Texas, requiring only 13 per cent. In this medley of requirements we find a variation of nearly 50 per cent and upon what fact of life or need are they based? Indeed, we must believe that these standards were established as compromises of judgment or as the opinion of the dominating member of the council. Not only in scattered cities do we find discrepancies in fat standards of cream, but in cities within the same state. Thus, Spokane demands 20, Seattle 18; Boston 15, Fall River 16; Houston 18, Beaumont 13; Detroit 18, Flint 20; St. Louis 15, Kansas City 18. Again we can imagine the struggle any dealer would have trying to meet competition and at the same time live up to such a medley of requirements. Cities located in different states but close together offer an even more distressing possibility. Thus, Kansas City, Missouri, requires 18 per cent fat in cream, while Kansas City, Kansas, is satisfied with 16 per cent; St. Louis, Missouri, 15 per cent and East St. Louis, Illinois, 16 per cent.

Consistently carried out, therefore, the basing of the ice cream standard upon the cream standard for the state and city in question would introduce at best a useless confusion, unwarranted by any real need or good to be done.

OTHER DAIRY FOODS

Other manufactured dairy foods are not dependent upon the composition of raw material for their standard, thus butter, whether churned from thin cream or thick cream, must not contain to exceed 16 per cent water, nor according to the United States Pure Food Law less than $82\frac{1}{2}$ per cent fat. Likewise,

cream whether extracted from Holstein milk testing 3.4 per cent, Shorthorn testing 4 per cent, or Jersey testing 6 per cent, must contain the quantity of fat specified in the ordinances of the city in which it is sold, and this we have noted, varies in general from 15 per cent to 20 per cent. In general, about 20 per cent of the volume of milk is extracted as cream, but if this simple proportion were maintained, we would have Holstein cream testing from 16 to 17 per cent fat, and Jersey cream testing from 26 to 30 per cent fat. In my judgment the fat content of cream should be based upon the needs of cream, not upon the fat content of the milk from which it was derived, just as the acid content of vinegar should be 4 per cent in order that it may preserve pickles rather than based upon the sugar content of the apples from which it was made, or in the case of white wine vinegar, the per cent strength of alcohol from which it was made.

Non-uniformity of requirements is one of the exasperating features of interstate commerce and few, if any, articles are already more tangled as to state requirements than ice cream. This is shown by the following list of states, with the fat standard of ice cream stated:

United States	No standard. All attempts to enforce circular 19, requiring, 14 per cent fat, have failed.
Alabama	14 per cent by reference to United States
Arizona	10 per cent for vanilla—8 per cent fruit, nut and chocolate
Arkansas	No standard.
California	10 per cent and 8 per cent
Colorado	14 per cent and 12 per cent
Connecticut	8 per cent and 6 per cent
Florida	12 per cent
Georgia	8 per cent
Idaho	14 per cent by reference to United States
Illinois	8 per cent
Indiana	8 per cent
Iowa	12 per cent
Kansas	14 per cent by reference to United States
Kentucky	10 per cent and 8 per cent
Louisiana	10 per cent and 8 per cent
Maine	14 per cent by reference to United States
Maryland	8 per cent and 6 per cent
Massachusetts	7 per cent

Michigan	10 per cent
Minnesota	12 per cent
Mississippi	8 per cent
Missouri	8 per cent reduced in 1919 from 14
Montana	10 per cent reduced in 1919 from 14
Nebraska	14 per cent and 12 per cent bill now in legislature to reduce
Nevada	14 per cent and 12 per cent
New Hampshire	14 per cent
New Jersey	No standard
New Mexico	No standard
New York	No standard
North Carolina	8 per cent
North Dakota	10 per cent and 8 per cent
Ohio	No standard
Oklahoma	10 per cent and 8 per cent
Oregon	8 per cent and 6 per cent
Pennsylvania	8 per cent and 6 per cent
Rhode Island	8 per cent
South Carolina	14 per cent by reference to United States
South Dakota	14 per cent and 12 per cent
Tennessee	8 per cent
Texas	8 per cent
Utah	14 per cent by reference to United States
Vermont	14 per cent by reference to United States
Virginia	8 per cent
Washington	8 per cent
West Virginia	8 per cent
Wisconsin	14 per cent by reference, 2 per cent tolerance allowed
Wyoming	10 per cent
Average	10 54 (the 42 States having standards considered)
Canada	10 per cent reduced from 14 about five years ago

ICE CREAM BASED ON OWN NEEDS

It is a fundamental law in the nutrition of animals of all species that three general classes of foods are needed, namely: ash for bone building, protein for muscle construction, and sugar, cellulose or fat for heat formation. Natural milk, which is universally conceded to be the most nearly perfect food, contains these various substances approximately in the proportions shown in table 1. Ash is present in minor but useful quantities. Sugar is present to the amount of about 4.88 pounds to 100 pounds of milk. Sugar does the same work as fat in the body, namely:

it furnishes energy for work and heat for warmth. Protein is the general name for casein, albumin, and the other minor similar substances. Its chief function is muscle building. Fat, about 3.69 pounds to the hundred, serves to produce heat, energy and fatness. The great difference between fat and sugar is that fat is $2\frac{1}{4}$ times more heating than sugar and is in general more difficult of digestion. Protein and sugar have heating powers practically identical. Therefore, by multiplying the fat content by $2\frac{1}{4}$ we have reduced it to the same terms as the other food nutrients, or, in other words, we have reduced the several substances to a common denominator and therefore can add them direct. Doing this, we find that the total starch value of 100 pounds of ordinary milk is about 16.43, or, in other words, 16.43

TABLE 1

Composition of milk

	per cent		*per cent*
Water	87.17		
Solid	12 83	Ash	0.71
		Sugar	4.88
		Protein	3.55
		Fat	3.69
Total starch value			16.43 pounds
Total energy value			29,804 calories
Nutritive ratio			1:3.7

pounds of dry starch or wheat flour would be required to equal 100 pounds of milk of this grade. The heat or energy value of foods is measured in calories of which this food contains about 29,804. The proportion, or ratio, between muscle producing and the heat producing foods is called the nutritive ratio and in average milk is about 1:3.7. For comparison we may study the composition and value of 20 per cent cream as shown in table 2, which we find has a starch value equal to 52 pounds, a total energy value of 94,328 calories, thus indicating a richer food; but likewise, we must note that there are 16.3 times as much heating food as muscle making food in cream of this grade, or, in other words, the nutritive ratio is 1:16.3.

Evaporated milk furnishes an excellent comparison with cream since it contains so nearly the same amount of total solids,

namely about 27 per cent, but differs from the cream chiefly in having a much higher protein content and lower fat content. This is shown in the starch value of 35.87 as against 52 and in the total energy of 65,068, as against 94,328. The proportion of muscle to heating properties in evaporated milk is shown to be about 1:3.8, practically identical with that of normal average milk. In this substance we have then high solids without high heating.

TABLE 2

Composition of 20 per cent cream

	per cent		per cent
Water	72.41		
Solids	27.59	Ash	0 59
		Sugar	4.00
		Protein	3 00
		Fat	20.00
Total starch value			52 00 pounds
Total energy value			94,328 calories
Nutritive ratio			1:16 3

TABLE 3

Composition average evaporated milk

	per cent		per cent
Water	73		
Solids	27	Ash	1.5
		Sugar	9.7
		Protein	7.5
		Fat	8.3
Total starch value			35 87 pounds
Total energy value			65,068 calories
Nutritive ratio			1:3.8

The composition of what we may term "old fashioned" ice cream, as shown in table 4 reveals a comparatively low ash, low protein, and high fat with an energy value of 98,718 calories, indicating a rich food, but with a ratio of nutrients indicating more than 17 times as much heating as muscle producing food. By comparing this with table 5, showing the composition of modern ice cream, we note that the ice cream which has been made up in part by the use of condensed or evaporated milk, and contains, therefore, higher proteins and a lower fat content

has only about 85 per cent as much heat in it per pound as the old style compound, or in other words, the 14 per cent fat ice cream contains about 20 per cent more heat than does modern ice cream. While an examination of the ratio or proportion of nutrients in the modern indicates that there are only about six times as much heating as muscle producing food, or, in other words, the nutritive ratio of the modern ice cream is about 1:6.0 as compared to 1:17.1 in the old style.

TABLE 4

Composition of "old fashioned" ice cream

	per cent			*per cent*
Water	63 75			
Solids	36.25	Ash		0 55
		Milk sugar	4.00	18.20
		Cane sugar	14 20	
		Protein		3.00
		Fat		14.50
Total starch value				54 42 pounds
Total energy value				98,718 calories
Nutritive ratio				1:17.1

TABLE 5

Composition of modern ice cream

	per cent			*per cent*
Water	64.80			
Solids	35.20	Ash		0.91
		Milk sugar	6.07	20.27
		Cane sugar	14.20	
		Protein		4.65
		Fat		9.40
Total starch value				46.4 pounds
Total energy value				84,142 calories
Nutritive ratio				1:6.0

High fat ice cream is hot; that is, contains a large quantity of heat units compared with that containing less fat, and since it is a generally recognized principle that people in summer should consume less fats and more fruits and cooling foods, it is directly in line with the advice of the health bureaus, dietetic experiments and physicians to maintain that ice cream, which is consumed most largely in summer for its cooling effect, should be chemically cool while being physically cold. Therefore, the fat standard

for ice cream, based upon the needs of the people eating the ice cream, would be comparatively low, say 8 to 10 per cent.

In conclusion, it seems clear that (1) a standard for composition is needed, (2) the composition should be based upon the needs of ice cream as a food and not upon some standard for cream, and (3) a fat percentage of 10 per cent for plain vanilla ice cream and 8 per cent for fruit, nut and chocolate ice cream is sufficient for all useful purposes.

TWO ORGANISMS OF A COMMERCIAL LACTIC STARTER

S. HENRY AYERS AND COURTLAND S. MUDGE

From the Research Laboratories of the Dairy Division, United States Department of Agriculture

It has become a more or less popular idea in this country that lactic starters consist of a single pure culture of a lactic acid producing organism, usually considered to be of the Streptococcus lacticus type. Nevertheless it has been recognized that not all pure cultures of this organism give the proper delicate flavor of a good starter.

In Europe, where the most extensive work on starters has been carried on, the general opinion seems to be that more than one organism is necessary for a good flavored starter. Storch (12) has shown that two types of organisms are concerned in a good starter; one a lactic acid producing organism and the other a type which was quite different but which when cultivated with the lactic type seemed to give the taste and flavor of a good starter. This flavor-producing type, which he called X bacteria, did not coagulate milk nor form much acid, but produced considerably more volatile acid than the lactic type. He also found that the lactic type produced a higher acidity when grown with the X bacteria.

Boekhout and De Vries (1) have isolated from sour milk and cream an organism which when grown with lactic acid producing organism of the *Streptococcus lacticus* type produced a characteristic and desirable aroma. This streptococcus resembled the lactic acid organism in morphology, but produced no visible change in milk.

Hammer and Bailey (6), while studying the volatile acid production in starters, found that cultures of the lactic acid producing type of organism, which they call B. lactis acidi, when isolated from starters gave a much lower volatile acidity in milk than did the starter itself. This they found to be true with a

number of commercial starters studied. After considerable difficulty they isolated an organism which, although it did not curdle milk, produced more volatile acid than did the lactic type. When grown with the lactic organism the volatile acidity was still further increased and also the total acidity. These two organisms which were isolated from the starter when grown in combination gave a volatile acidity similar to that secured from the starter itself. This work suggests that perhaps the commercial starters in the United States consist of more than one type of organism. It is possible that the volatile acid producing organism isolated by Hammer and Bailey is of the same type as the X bacteria described by Storch, and the aroma producing organism isolated by Boekhout and De Vries.

It is the purpose of this paper to describe two organisms isolated from a commercial starter which when grown together seem to reproduce the desirable characteristics of the original starter both in regard to activity and flavor.

THE TOTAL AND VOLATILE ACIDITY PRODUCED BY THE ORIGINAL STARTER AND TWO CULTURES ISOLATED FROM IT

While engaged in an attempt to secure an active organism of the lactic type from a commercial starter, we found that while this was easily accomplished the culture did not give the delicate flavor of the original starter. This emphasized the fact that some other organism was of importance in connection with a desirable flavor. Plates were then made using a milk powder agar,[1] and the starter examined at different stages of its development during a twenty-four-hour period. The appearance of the plates showed that there were two distinct types of colonies. One type was surrounded by a small white zone, which on the milk powder medium indicates a high acid production. The other type of colony showed no such zone. The appearance of the paper by Hammer and Bailey (6) at this time led us to make determinations of the volatile acid produced by these two types

[1] Directions for the preparation of milk powder agar can be found in the Journal of Bacteriology, v, no. 6, 565–588.

of organisms, both of which were streptococci. These cultures were inoculated into sterile skimmed milk and incubated for twenty-four hours at 30°C. and then steam distilled. In order to make our results comparable to those obtained by Hammer and Bailey, we followed their method of steam distillation, using

TABLE 1

Comparison of fermented milks prepared by the use of a commercial starter and two organisms isolated from it used separately and in combination

CULTURE	INOCULATION	ACIDITY, AS LACTIC ACID	VOLATILE ACID, CC $\frac{N}{10}$ NaOH NEUTRALIZED.	EFFECT OF CULTURE ON MILK	FLAVOR
		per cent	*cc.*		
Commercial starter	1 cc. 24-hour old culture to 350 cc. sterile skimmed milk	0 82*	25 1	Firm curd, indication of little gas	Sharp pleasant acid, but delicate flavor
Culture "L"	1 cc. 24-hour old culture to 350 cc. sterile skimmed milk	0 86*	7.0	Firm curd, no gas	Sharp, clean acid flavor
Culture "A"	1 cc. 24-hour old culture to 350 cc. sterile skimmed milk	0 23	7 5	Not coagulated, very little increase in acidity	Not sour
Combination of culture "L" and culture "A"	1 cc. of each 24-hour old culture to 350 cc. sterile skimmed milk	0.87*	23 8	Firm curd, indication of little gas	Sharp pleasant acid, but delicate flavor

* The per cent of lactic acid varied and was often higher than in this particular experiment.

250 cc. of milk culture and titrating the volatile acid obtained from 1,000 cc. of distillate.

From the results shown in table 1 it will be seen that the commercial starter produced a total acidity of 0.82 per cent, calculated as lactic acid, and 25.1 cc. volatile acid, the volatile acid being expressed in terms of $\frac{N}{10}$ NaOH, neutralized by the volatile

acid in 1,000 cc. distillate from 250 grams of the milk culture. The culture showed a firm curd with *indication of a little gas* and had a sharp, pleasant acid but delicate, flavor.

Culture "L" was from one of the colonies on the milk powder agar plate which showed a white zone around it. This culture, when inoculated in sterile skimmed milk and handled in the same manner as the commercial starter from which it was obtained, gave an acidity of 0.86 per cent with a volatile acidity of 7 cc. of $\frac{N}{10}$ NaOH. The culture showed a firm curd with *no indication of gas* and had a sharp, clean acid flavor, but lacked the delicate flavor of the original starter.

The other organism, Culture "A," isolated from the starter from a colony showing no white area about it, was of considerable interest to us. It produced an acidity, in sterile skimmed milk, of only 0.23 per cent, calculated as lactic acid, and a volatile acidity of 7.5 cc. of $\frac{N}{10}$ NaOH. The milk was not coagulated and not sour to the taste.

When these two cultures "L" and "A" were grown together the results obtained duplicated the action of the original commercial starter, as will be observed from the figures in table 1. The volatile acidity was practically the same as that of the original starter, while there was a similar firm curd with an *indication of a little gas*. The soured milk, according to the opinion of several persons who examined it, had the same sharp pleasant acid, but delicate, flavor of the original starter.

GAS PRODUCTION IN THE STARTER

It will be noted that in the original starter the appearance of gas was observed in the curd. A few gas bubbles could be seen on the side of the flask and often stripes in the smooth curd indicated the escape of gas at that point. In the dairy and the laboratory suspicion might be cast upon a starter showing this evidence of gas formation and the tendency would be to call it contaminated. This same gas formation, however, took place in the starter made from a combination of pure cultures "L" and "A." We were not at all surprised at this gas formation,

because it is known that gas formation by the streptococci is not uncommon. Freudenreich (5) found gas-forming streptococci in kefir, and Miss Evans (4) has shown that gas-producing streptococci of the Streptococcus kefir type are common in cheese, while Jensen (8) states that Streptococcus cremoris, which is commonly found in commercial starters, can develop such a quantity of carbonic acid that fine stripes appear in the curd. It has also been found in the course of our studies of the milk streptococci that CO_2 producers are very common in certain kinds of milk and from our knowledge of this type of organism, culture "A" rather than "L" was selected as the probable gas-forming organism.

TABLE 2

Carbon dioxide production from 15 cc. of sterile skimmed milk inoculated with various cultures

MEDIUM	CULTURE "L"	CULTURE "A"	CULTURES "L" AND "A"	ORIGINAL COMMERCIAL STARTER
	*cc.**	*cc.**	*cc.**	*cc.**
Plain skimmed milk	0.0	0.7	2 3	4.9
Skimmed milk with 0.5 per cent peptone	0.4	7.5	4.1	5.1

* Cubic centimeters of $\frac{N}{10}$ Ba $(OH)_2$ neutralized by CO_2. Determinations made in Eldredge tubes.

Experiments showed, as will be noted from table 2, that a little CO_2 was produced in skimmed milk by culture "A" alone and that it was greatly increased when grown with culture "L" which showed no CO_2 formation. In peptone milk CO_2 production was greatly stimulated by peptone, a fact which Miss Evans observed with Streptococcus kefir. The formation of CO_2 was determined by the use of fermentation tubes described by Eldredge and Rogers (3), and we highly recommend these tubes for the routine determination of small amounts of CO_2 produced by bacterial action.

It seems evident from these results that the indication of gas formation in a starter does not necessarily mean contamination. On the other hand, it may indicate the proper development of a type of streptococcus which is essential in a good flavored starter.

It is possible that cultures can be found which do not produce CO_2 but which may possess the other desirable features of the culture under discussion.

CHARACTERISTICS OF THE CULTURES

Culture "L"

Colonies on milk powder agar. Colonies are small but have a distinct white zone about them. This indicates high acid production.

Morphology. Twenty-four-hour old milk culture.

The organism is a streptococcus of medium size and ovoid in shape. Chains of 4 to 8 cells are commonly found and often chains up to 20 cells.

Growth in litmus milk. Grows rapidly and decolorizes the litmus often before coagulation. Grows at 10°C. After twenty-four hours at 30°C. in skimmed milk an acidity of about 0.86 per cent (as lactic acid) is reached.

Fermentations. Ferments dextrose and lactose. Does not ferment saccharose, salicin, mannite, raffinose, or inulin.

Carbon dioxide production from milk. Negative.

From the characteristics of culture "L," particularly its reducing action in litmus milk, its growth at 10°C., and the lack of ability to ferment saccharose, it seems evident that the culture belongs to the Streptococcus lacticus group. Sherman and Albus (11) have shown that the three characteristics mentioned are of importance in distinguishing the organisms of the Streptococcus lacticus type from other streptococci.

Culture "A"

Colonies on milk powder agar. Colonies are small but do not show any white zone. This indicates little or no acid production.

Morphology. Twenty-four-hour old milk culture.

The organism is a coccus a little smaller than culture "L." It occurs frequently in chains of 4 to 8 and sometimes as high as 32 cells. The cells are ovoid in shape.

Growth in litmus milk. In twenty-four hours at 30°C. there is only a slight change in the color of the litmus. After seven days' incubation

the reaction is distinctly acid, but milk not coagulated. After twenty-four hours at 30°C. in skimmed milk an acidity of about 0.23 per cent (as lactic acid) is reached. The culture grows slowly in milk at 10°C. In skimmed milk with 0.5 per cent peptone an acidity of about 0.47 per cent is produced in twenty-four hours.

Fermentations. Ferments dextrose and lactose. Does not ferment saccharose, salicin, mannite, raffinose, or inulin.

Carbon dioxide production from milk. Positive.

Culture "A" did not grow in any of the ordinary media commonly used for fermentation tests. It was found, however, that the addition of casein to an extract peptone solution gave a medium which supported growth when a sugar was present which could be fermented. The composition of the medium was as follows: 0.5 per cent Fairchild peptone; 0.3 per cent meat extract; and 0.1 per cent casein, reaction pH 7.5. The casein solution was prepared by dissolving 5 grams of Hammarsten casein with 1 gram of sodium dibasic phosphate (Sorenson's phosphate $NA_2HPO_4 + 2H_2O$) in 100 cc. of distilled water. Enough of this solution was added to the medium to give 0.1 per cent of casein.

Culture "A" resembled the gas-forming streptococcus found by Freudenreich (5) in kefir and called by him Streptococcus B, which Migula (10) has named Streptococcus kefir. It agreed in most respects with the strains of Streptococcus kefir isolated from cheese by Miss Evans (4) but differed so far as it did not ferment saccharose and seemed to grow in artificial media with more difficulty. It was further observed by Miss Evans that the Streptococcus lacticus type of organism produced about 0.12 grams of acetic acid in milk while one of the Streptococcus kefir cultures produced 0.97 gram per 3,000 cc. of milk containing 0.5 per cent peptone.

It was found that, when grown in skimmed milk with 0.5 per cent peptone for seven days at 30°C., culture "L" (Streptococcus lacticus) produced about 0.32 gram of acetic acid per liter, while culture "A" produced about 1.1 grams of acetic acid and a small amount of propionic acid.[2] The acetic acid of a control flask

[2] We are indebted to Mr. McNair of these laboratories for these determinations.

of medium was not determined, but as the medium was the same in both cases, the results can be compared.

With our present knowledge of the two cultures it seems safe to say that culture "L" represents a strain of the Streptococcus lacticus type and culture "A" a strain of the Streptococcus kefir type.

THE ASSOCIATIVE ACTION OF THE CULTURES

The associative action of bacteria is extremely interesting. Marshall (9) and his associates have made extensive studies of this subject, while Hammer (7) and also Buchanan and Hammer (2) have observed associative action.

TABLE 3

Effect of peptone in milk on the activity of Culture "A" as shown by the examination of twenty-four-hour old cultures at 30°C.

MEDIUM	ACIDITY AS LACTIC ACID	VOLATILE ACIDITY, CC. $\frac{N}{10}$ NaOH NEUTRALIZED BY 1000 CC DISTILLATE FROM 250 GRAMS OF CULTURE	BACTERIA PER CUBIC CENTIMETER AFTER INOCULATION	BACTERIA PER CUBIC CENTIMETER AFTER 24 HOURS INOCULATION AT 30°C.
	per cent	*cc.*		
Skimmed milk*..................	0 23	7 5	346,000	85,000,000
Skimmed milk and 0.5 per cent peptone*.....................	0 47	37 1	163,000	311,000,000

* Inoculated with 1 cc. of a twenty-four-hour old culture to 350 cc. of medium.

Hammer and Bailey (6), in their study of commercial starters. isolated two organisms which in combination gave a volatile acidity similar to that of the original starter. Each of these cultures alone, however, gave a volatile acidity considerably below that of the original starter. They also found that the acidity, calculated as lactic acid, was increased by the associative action. A similar increase was observed by Storch (12).

As has been shown the two organisms under discussion in this paper acted in a similar manner so far as volatile acidity was concerned, and the associative action was plainly evident. We did not find that the acidity calculated as lactic acid was increased to any extent.

A few experiments which were tried throw some light on the increase in volatile acidity. From the results in table 3 it may be seen that when 0.5 per cent peptone was added to skimmed milk the acidity was about doubled and the volatile acidity increased about five times. The bacterial growth was also much more rapid as is shown by the bacteria counts on milk powder agar.

It is seen therefore that associative action with culture "L" (Streptococcus lacticus) was not necessary to increase the volatile acidity when peptone was added to the milk. Evidently the skimmed milk did not contain a readily available source of nitrogen for culture "A," which was supplied by the addition of a small amount of peptone. On this theory it may be possible to explain the associative action of the two cultures by assuming that through the growth of culture "L" the complex nitrogenous material of the milk was converted into lower forms which were more desirable sources of nitrogen for culture "A." The growth of this organism was therefore stimulated and the volatile acidity increased.

SUMMARY

1. Two cultures of streptococci were isolated from a commercial starter. These two cultures seemed to be necessary in order to reproduce acidity and flavor of the original starter.

2. One culture was evidently a strain of the Streptococcus lacticus group. It produced a high acidity in milk and but little volatile acidity.

3. The other culture seemed to correspond to organisms of the Streptococcus kefir type. It produced but little total acidity in milk and when grown with the Streptococcus lacticus culture produced considerable volatile acid.

4. Gas was observed in the original starter. This was undoubtedly due to the growth of the organism of the Streptococcus kefir type, since when grown with the Streptococcus lacticus culture there was a gas formation similar to the original starter. It was further observed that carbon dioxide was formed by the culture when grown in peptone milk.

5. Associative action between the two cultures was very noticeable. The results indicated that the Streptococcus lacticus type through its growth converted the nitrogenous material of the milk into a form more available for the Streptococcus kefir type and as a result the growth of the latter was increased.

6. The results reported represent a study of only one commercial starter. It remains to be determined whether the cultures are the same in all starters.

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HISTORICAL NOTES ON COTTON SEED AS FOOD[1]

ICIE G. MACY

From the Sheffield Laboratory of Physiological Chemistry, Yale University, New Haven, Connecticut

THE USE OF COTTON SEED

Commercial utilization of cotton seed dates back to the middle of the nineteenth century, when the oil was first successfully expressed. Up to that time the cultivation of the cotton plant was for the cotton alone, the seeds being left to decay and yield fertilizer. One of the very early attempts to make use of the oil from the cotton plant was that of the Antilles of the British West Indies (Du Tertre, 1667) who made oil from the flower of the cotton plant and used it as a medicament for old ulcers. It was one hundred years or more before people began to investigate the various oleaginous seeds and to devise methods for dividing them into the oil and the oil cake. One of the first endeavors was that of the Moravians (Bishop, 1866) at Bethlehem, Pennsylvania, who, in 1769–1770, gave exhibits of specimens of oil which they had made from various oleaginous seeds. Among the exhibits was a sample of cotton seed oil that they had expressed from the decorticated seeds at the rate of nine pints of oil to a bushel-and-a-half of seeds. At the same time a sample of the oil was presented to the American Philosophical Society for the purpose of emphasizing the worth of the cotton seeds in their oil content.

The value of the residue, after the oil had been expressed from the cotton seed, next became of interest, especially to the agriculturist. The Royal Society of Arts of London (1783) was the first organization to foresee the true value of the cotton seed cake; and in the proceedings of that society for 1783 there is the following offer:

[1] Parts of this paper were taken from the dissertation submitted by Icie G. Macy for the degree of Doctor of Philosophy, Yale University, 1920.

The society being informed that a considerable quantity of oil can be obtained from Seeds of Cotton, and that after the expression of the oil, the remaining cake will afford a strong and hearty food for cattle; and likewise, that the apparatus for the operation can be applied to the mill for sugar canes, and worked in the rainy season, at a moderate expense; have resolved, for the foregoing reasons, that the procuring oil from the Seed of Cotton is a proper object of a premium, considered as an encouragement for planters to the cultivation of cotton, an article essentially requisite to increase manufacture of that commodity in this country.

The society therefore offers as follows:

Oil from cotton seed

To the planter in any of the British islands of the West Indies, who shall express oil from the Seed of Cotton, and make from the remaining seed hard and dry cakes, as food for cattle; the gold medal.

Certificates that not less than one ton of the oil has been expressed, and five hundred weight of the cakes obtained, to be produced to the society, with two gallons of the oil, and two dozen of the cakes, together with a full account of the process, on or before the last Tuesday in November, 1785.

For the next greatest quantity, not less than half a ton of oil, and two hundred weight of the cakes; the silver medal.

The premiums were annually renewed for six years but the large quantity required appears to have defeated the object, as no awards were made. In 1785 a similar premium was offered in this country by the South Carolina Agricultural Society (Bishop, 1886). Nevertheless, it was not until 1819 that a patent was taken out for the preparation of cattle food from cotton seed, and in the following year another was taken out for the extraction of oil from the same seed. As a matter of fact the oil was not expressed on a commercial scale until the middle of the nineteenth century and since then the growth of the industry has been phenomenal, particularly in America. A new source of profit to the southern cotton planter has been founded in the manufacture of cotton seed oil and pressed seed cake from

many tons of seeds which had before been valuable only as fertilizer.

The cotton seed cake from which the oil has been expressed contains all of the fiber and mineral matter of the seed, the residue of oil or fatty material not extracted, and, what gives it special value, the nitrogenous constituents. It is stated that one short ton of cotton seed, constituting about 40 per cent of the raw cotton, will yield 800 pounds of cotton seed cake and 45 gallons of crude cotton seed oil.

After the introduction of cotton seed meal on the market for feeding live stock, attention was next directed to the possibilities of decorticated cotton seed meal as a food for human beings by the late Colonel J. W. Allison, one of the pioneers of the cotton seed oil industry in the United States. He put cotton seed flour on the market as an article of food for human consumption in 1876. Since cotton seed flour contains little or no starch but about 54 per cent of crude protein it has been prescribed in medical cases where a starch-free diet is necessary, and has been used to some extent as a diluent for wheat flour. Experiments on the dietetic value of cotton seed flour for human beings have not been carried out for sufficiently long periods of time to enable final conclusions to be drawn.

Preparation of cotton seed products

The cotton seed *kernels* are obtained by decorticating the whole cotton seeds and freeing them from most of the hulls and lint. After the greater portion of the oil has been expressed from the kernels, a product known as the cotton seed *press cake* is obtained. This contains all the crude fiber and mineral matter of the seed, the residue or the fatty material not extracted, and a large quantity of nitrogenous constituents. The press cake is available in slab form, or is cracked coarsely or finely, or ground into *meal.* The *meal* is put through an intricate process of refining and bolting to produce the cotton seed *flour.*

Two processes are commonly used in the preparation of cotton seed meal. The so-called "cold pressed" meal is made by passing

the decorticated kernels through pre-heaters surrounded by steam under pressure. The dry kernels are then ground up in a screw press to express the oil. In this procedure, heat is generated, owing to the great amount of friction in the grinding. In the second process, after the whole kernels have been decorticated and crushed, the kernels themselves are subjected to steam pressure for about thirty minutes. After this treatment they are then emptied into the "cake former" where the oil is expressed and the residue pressed into cakes. According to Withers and Carruth (1918b), the actual temperatures in the hot and cold processes do not differ greatly. The cold pressing is really a dry pressing rather than a moist pressing.

The problem involved in the feeding of cotton seed meal

As soon as the oil from the cotton seeds was expressed in commercial quantities, the residual oil cake was put on the market in vast quantities as a cheap food for cattle, hogs, sheep, and other domestic animals. Although this commodity has been used in the south for many years, it is only within recent years that use has been made of it in the north and west. In the past a very large proportion of the cotton seed meal produced in America has been exported. The European feeders were the first to show their appreciation of this concentrated foodstuff as a food; for they were willing to purchase it in this country and pay freightage to Europe in order to have it for feeding purposes. However, when the farmers began using cotton seed meal in large quantities difficulty was encountered; the mortality of certain species of animals was increased owing to the so-called "cotton seed meal injury."

The first published notice dealing with the injurious effects of cotton seed meal seems to have been reported in England by Voelker in 1859 (Crawford, 1910). Since that time many cases have been reported, and for the past forty years vigorous attempts have been made to ascertain the direct cause of "cotton seed meal injury" and its effect upon the animal organism. Owing to the variability of effects on animals consuming similar amounts of cotton seed meal, the tardiness in appearance of abnormal

symptoms in some cases, and the lack of consistently uniform results, compatible studies are difficult.

Numerous experiments have been conducted on swine; of all the farm live stock these animals are the most sensitive to the deleterious effects of cotton seed meal. In the light of our present knowledge, hogs may be allowed to eat small quantities for short periods of time with profit, but it is never advisable to feed growing pigs as a rule on cotton seed meal.

Among individuals of the same species of animals there is the most notable variation in the effects of cotton seed meal upon the animal organism. This is particularly true in the case of cattle. Milch cows during lactation may feed for prolonged periods upon this foodstuff without any deleterious effects; steers will fatten for a short time, but if the period is prolonged injury results; and many deaths result among young calves. Dinwiddie and Short (1911) report that cows as well as other live stock possess a relative immunity during lactation. However there has been no solution to the problem which will explain the difference between susceptibility of fattening cattle and young calves. Tietze (1893) found that calves from nine to twelve months are most susceptible. The more recent investigators advise that cotton seed meal should be fed very sparingly and with extreme caution to young calves until more is learned concerning its toxicity. Sheep are less sensitive to the ill effects of cotton seed meal. Gray and Ridgeway (1910) report feeding large amounts to sheep with few fatalities. Other investigators have had similar experiences.

The results of experimenters in feeding cotton seed meal to poultry are very diverse. However, the consensus of opinions is that it should never be fed in large quantities. Opinions differ as to its effect upon pullets developing and coming to laying maturity, the effect upon egg production, and the loss of flesh. Ahrens (1917) reported the mortality of chicks very high on both normal and excessive cotton seed meal rations. However, our knowledge is very limited as to exact cause of such results.

Cotton seed meal is most actively toxic to rabbits and guinea pigs, as shown by a large number of investigators and also by

this author whose data are yet unpublished; while the same sample may or may not be injurious when fed to mice and rats. No human fatalities have resulted from the use of cotton seed flour in so far as I am able to ascertain, perhaps due to a low content of the toxic substance gossypol which will be discussed later, or because it has not been eaten for long enough periods of time or in sufficient amounts to enable final conclusions to be drawn as to its dietetic value or possible harmful qualities. Since experiments with cotton seed meal on lower animals reveal such deleterious properties, it would appear wise to use cotton seed flour sparingly until our knowledge regarding the whole problem of cotton seed meal injury has been more satisfactorily investigated than it has at the present day.

SPECULATIONS AS TO THE CAUSES OF COTTON SEED MEAL INJURY

Review of previous work

Our knowledge is very limited as to the causes of cotton seed meal poisoning although it has been a subject for investigation for many years. One of the earliest attempts to solve the problem was made by R. Böhm (1881) who, in 1881, discovered cholin in cotton seed and was the first to suggest the poisonous nature of this compound in cattle food prepared from cotton seeds. He states having received from a druggist an alcoholic extract from a cattle food prepared from cotton seed which had been fed as a diet to young cattle in Germany and had proved fatally poisonous. From this alcoholic extraction a large preparation of cholin was made, and Böhm concluded that only one base was present. Nevertheless one year later, in 1882, Ritthausen and Weger (1884) succeeded in obtaining a very large yield of betaïn. Although betaïn is nonpoisonous, as was pointed out by Gaehtgens,[2] in 1870, investigators (Wiley) suggested that cholin is the original base formed and betaïn is a secondary product, and they presumed that in all cases of cotton seed

[2] Gaehtgens, Dorpater medicin. Zeitschr., 1870, Bd. i.

meal poisoning a meal had been fed in which cholin was relatively more abundant than betaïn.

Maxwell (1891) reported a more extensive study of these nitrogenous bases, the object being to learn their relative proportions in cattle food prepared from cotton seeds and to study the physiological effects of cholin. He estimated the mixed chlorides of cholin and betaïn as 0.24 per cent and the proportions of the two bases as 17.5 and 82.5 per cent, respectively. In experiments on cats, Maxwell (1891) found that 0.3 gram of the cholin which he had prepared from cotton seed was sufficient to paralyze a strong cat and that 0.5 gram would produce immediate death.

It has since been shown that cholin does not exert a poisonous action upon animals when fed by mouth; however, when injected subcutaneously it has toxic properties. Moreover the toxic action of cotton seed meal does not induce the clinical symptoms and pathological lesions that correspond to the poisonous action of cholin. As a matter of fact, Von Hoesslin (1906) reported a series of experiments in which he found the chlorate of cholin much more toxic than the cholin alone; furthermore 2 grams of cholin hydrochlorate could be fed by mouth to rabbits with no serious results. Thus the quantity of these compounds found in cotton seed meal is far too small to account for the toxicity of the various cattle foods.

Brieger (1886) suggested the possibility of cholin decomposing into neurin, a toxic compound, but was unable to demonstrate such a conversion. Modrakowski (1908) likewise was led to a similar conclusion. Basing his theory on a series of experiments in which he found freshly prepared cholin to be less toxic than old cholin concluded that the symptoms of cotton seed meal poisoning result from ptomaines which have a neurin- or a muscarin-like action. Friemann (1909) similarly reported that ptomain substances are probably formed from the nitrogen-containing components of the lecithin in the meal. He also suggested that unsaturated fatty acids present in the fat extracted from cotton seed meal have some relation to the sum total of the toxic action.

An investigation of cotton seed meal with regard to its high protein content was made by Tietze (1893). In the summer of 1893 he investigated several cases in which the death of young calves was attributed to the use of cotton seed meal and found that the calves received 3 heaping liters of this meal in addition to skim milk, hay and linseed cake. The trouble was believed to be due to the high protein content of the cotton seed meal.

A belief is also prevalent that the harmful effects of cotton seed meal as a feeding stuff is due to the fibers therein, and that they sometimes cause great trouble in animal feeding by obstructing the intestinal tract. The amount of fibers in this particular feed may vary from 2 to 25 per cent. However, no cotton fibers have been found on autopsy in the intestine of the animals which have died of cotton seed poisoning.

The findings of Namêche (1900) on young cattle, rabbits, a goat, cow, and pigs led him to conclude that cotton seed meal in itself was not harmful, but that the poisonous properties are due to carelessness on the part of the feeders, ignorance in the use of cotton seed meal, or a lack of cleanliness.

Other speculations were made by Zopf (1882) and Von Nathusius (1885). From their work they attributed the poisonous action of cotton seed meal to parasitic organisms found in the meal. Edgerton and Morris (1912) have fed cotton seed meal infected with molds that usually grow on the cotton plant to rabbits, and guinea pigs, and found that such parasites do not increase the toxicity of cotton seed meal.

In 1903 König, Spickermann, and Olig reported a very complete study on the decomposition products of cotton seed meal by different sorts of microorganisms. They found that all the organisms investigated gave similar physiological effects, were affected by the composition of the meal, and by the air supply. All the bacteria that attacks the proteins of cotton seed meal cause the following cleavage products; albumose, peptone, amines, volatile fatty acids such as butyric and valeric acids, aromatic acids as phenylacetic and phenylpropionic acids, succinic acid, skatolcarbonic acid, aromatic oxyacid, indol, skatol,

phenol, ammonia, carbon dioxide, and volatile sulphur compounds. However, at no stage of decomposition of cotton seed meal, the authors conclude, were poisonous substances formed by bacteria commonly present as shown by physiological experiments.

Barnett (1909), in studying the effect of cotton seed meal fed in large quantities to dairy cattle, obtained results which point to the fact that this material contains a specific toxin affecting, firstly, the lymphatic glands draining the digestive tract, and secondly, the lungs.

The injury resulting from the feeding of cotton seed meal has been attributed to oil content. Lendrich (1908) found that rabbits became emaciated when cotton seed meal was administered daily. Even though Cowie and Munson[3] alleged that the administration of oil interfered with digestion in man, this alone could not explain the toxicity of cotton seed meal. Alsberg and Schwartze (1919) in their recent pharmacological studies of gossypol, a phenolic compound found in cotton seed, administered this compound in oily solution by stomach tube to rats. Even small doses were fatal; for the animals died a few days later. Post mortem examination revealed the fact that both the oil and the gossypols still remained in the stomach, for both were re-isolated. Evidently either the oil or gossypol or perhaps both interfered with digestion. Gossypol will be discussed at length later in the paper.

Many speculations have been made as to the poisonous action of the compounds of phosphorus contained in cotton seed meal, inasmuch as phosphorus is such an important constituent, as has long been recognized. In 1890 Dancy (1890) called attention to the fact that phosphoric acid acted differently from orthophosphoric acid.[4] This was followed up by Harding (1892) who suggested that some of the peculiar, and in certain cases injurious and even fatal effects produced by the use of cotton seed and cotton seed meal as feeding stuffs may be due, in a

[3] Cowie, D. M., and Munson, J. F. Archives Internal Med., 1908, i, 61.

[4] Starkenstein, Biochem. Zeitsch., 1911, xxxii, 243, has demonstrated that orthophosphoric acid to be only slightly toxic.

measure at least, to the presence of meta- and pyro-compounds,[5] but no experimental data are given to ratify his belief.

Crawford (1910) in studying the toxicity of cotton seed meal on rabbits concluded that the chief poisonous principle is a salt of pyrophosphoric acid. The fact that some meals are more toxic than others was thought to be due to the conversion of ortho- into the meta- and pyrophosphoric acids by the heat during the process of manufacture.

Other investigators reported experiments to prove that the phosphoric acids are not the cause of cotton seed meal injury. In a series of investigations which extended over a period of two years, Edgerton and Morris (1912) found no evidence whatsoever that pyrophosphoric acid had anything to do with the poisoning. In the same year Rather (1912), after a study of the forms of phosphorus in cotton seed meal by various extraction processes, stated that there is no evidence that cotton seed meal injury is due to either pyro- or metaphosphoric acids.

Withers and Ray (1913) conducted an extensive series of experiments in which particular attention was laid on the phosphoric acid content. Rabbits were fed cotton seed meal, aqueous extracts, pepsin-pancreatin digestion products, residue after ammonium citrate extraction, and finally amounts of pure sodium pyrophosphate corresponding to that in the cotton seed meal. These investigators found that the pepsin-pancreatin extract is non-toxic to rabbits under ordinary conditions of feeding. The residue undigested by pepsin-pancreatin is more toxic than the material made soluble by digestion and is definitely harmful when fed in normal amounts A meal may prove to be poisonous upon experimentation but still contain a non-toxic amount of the pyrophosphoric acid salts. This investigation proves quite conclusively that under ordinary conditions, the pyrophosphoric acid is not responsible for the toxicity of cotton seed meal.

[5] Gamgee, Priestley, and Larmuth, Jour. Anat. and Phisol., 1876, ii, 255, had previously demonstrated that sodium meta- and pyro- phosphates were very toxic to rabbits when injected into the animal but not toxic when fed by mouth. This was later corroborated by Schultz. Arch. Exper. Pathol., 1884, xviii, 174.

The work of Withers and Ray (1913) was corroborated by Symes and Gardner (1915) in their study of the toxicity of sodium pyrophosphate administered in food to rabbits, rats, and cats. Cotton seed meal proved fatal to rats when fed as an exclusive diet; even 5 grams of cotton seed meal per head daily supplemented with oats and bran were fatal; similarly meal after previous extraction with alcohol and ether, fed with oats and bran caused death, though not so early. The P_2O_5 content of the cotton seed meal amounted to 0.022 gram in the daily ration, a quantity which corresponds to 0.07 gram of sodium pyrophosphate, less than one-seventh of the quantity tolerated by rats which consumed daily 0.5 gram per head of crystalline sodium pyrophosphate for a period of 9 weeks without harm. The experimenters (Symes and Gardner, 1915) concluded that since the toxicity can be reduced by extraction with alcohol and ether and the phosphate is present in such small quantities the chief poison of the meal is not pyrophosphate.

Anderson (1912) described the isolation of an unidentified phosphoric acid from cotton seed meal and its decomposition into inositol and phosphoric acid when heated in a sealed tube. The aqueous solution of the free acid gave all those reactions which have been attributed previously to the presence of pyro- and metaphosphoric acids in cotton seed meal. When it was given in 0.5 and 1 gram doses to rabbits symptoms of distress were produced, but the animals recovered their normal appearance in two or three hours. There is no conclusive evidence that this particular phosphoric acid is the cause of cotton seed meal injury.

In 1915 two theories arose, firstly, that cotton seed meal poisoning is a deficiency disease, as set forth by Rommel and Vedder (1915) and later supported by Wells and Ewing (1916); secondly, that it is due to a definite phenolic compound, gossypol, found in cotton seed meal, as shown by Withers and Carruth (1915).

Is cotton seed meal injury a deficiency disease?

Rommel and Vedder (1915), basing their conclusions upon the similarity of post mortem observations on pigs that died of

cotton seed meal poisoning with those of beriberi on man, believe "that the so-called cotton seed poisoning of pigs is a deficiency disease, analagous to the disease known as beriberi in man, if not identical with it. Acute cotton seed poisoning corresponds to wet beriberi, and the chronic form to dry beriberi. The cause of the so-called cotton seed poisoning is probably a deficiency in the ration." These investigators fed pigs upon polished rice, a ration deficient in vitamine, and a disease resembling beriberi in man resulted. They believe that pigs develop this deficiency disease as do human beings, but much more quickly. The symptoms and post mortem observations on the pigs that had died on the polished rice were very similar to those that had died of cotton seed meal poisoning. The following explanation of the condition was offered:

> The grain with which the cotton seed meal is most frequently combined is corn. Corn is notoriously deficient as a single feed for animals, and it must be properly balanced to be fed satisfactorily. The excellent results in feeding pigs which can be obtained from rations of corn meal and skim milk or other animal products, such as tankage, blood meal, fish meal, etc., are out of all proportion to the facts indicated by the conventional chemical analyses of protein, carbohydrate, and fat. When corn meal is fed with cotton seed meal, a combination is made of two feeds both of which are deficient.

The writers do not commit themselves further as to what component is lacking in cotton seed meal.

Wells and Ewing (1916), after feeding diets of cotton seed meal with sugar, starch and a little milk to very young pigs, concluded that the meal was an incomplete food; expressed in their own words,

> This is true even when it is fed with sugar and starch to a wide nutritive ratio. Pigs upon an absolute maintenance diet ate in addition only small quantities of cotton seed meal and were not injured by it. So-called cotton seed meal injury is due in large part to inadequate diet.

Gossypol, a toxic substance in cotton seed

Kuhlmann (1861) showed that cotton flower as well as other portions of the cotton plant contained a yellow dye which, by action of acids, is converted into the so-called "cottonseed blue."

This was further examined by Marchlewski (1899) who isolated a crystalline product by purifying the phenolic constituents of cotton seed oil by repeated fractionation from acetic acid solution. To this golden crystalline substance, he gave the name gossypol, on account of its source and phenol properties. It dissolves in ordinary fat solvents. Withers and Carruth (1915) have isolated it from cotton seed kernels and found it to be very toxic to rabbits, rats, guinea-pigs, and pigs whether fed in the form of gossypol acetate, crystalline gossypol, or gossypol-containing extract. The same investigators (1918a) found that cotton seed kernels contain about 0.6 per cent gossypol; ether extraction renders the kernels non-toxic to rats and gives a highly toxic extract containing about 2 per cent gossypol.

Gossypol is quickly oxidized in solution of sodium hydroxide as shown by Marchlewski (1899) and later corroborated by Withers and Carruth (1915). The latter experimenters state that alcoholic-alkaline treatment very greatly diminishes, if it does not entirely remove, the toxic properties of cotton seed meal, owing to the oxidation of gossypol into a non-toxic substance.

Carruth (1918) in his work on the chemistry of gossypol, was able to isolate only very small traces of gossypol, as such, in certain cotton seed *meals*, yet the food products were definitely injurious to rabbits and pigs, but he isolated an oxidized product which he called "D" gossypol, the source of which is explained by the fact that during the process of manufacture of the meal from the kernels, gossypol is converted into "D" gossypol. This modified form is toxic to rabbits and swine but has little action on rats. Here a conspicuous feature of indefiniteness and unlike response of different species arises. Why should rabbits and swine not only respond to the gossypol in the kernels but also to the altered gossypol in the cotton seed meal, while rats are not affected by the latter? Many attempts have been made to render cotton seed meal non toxic, but none have been successful for all species alike. Withers and Ray (1913) found that boiling with alcoholic alkali was the most successful method of

treatment. This seems to be the only process out of a large number that rendered the meal harmless.

Withers and Brewster (1913) fed iron salts, copperas and ammonium citrate with cotton seed meal and found that the toxic factor was more or less inhibited in the case of rabbits and swine. After eliminating the toxic factor their results show no evidence of nutritive deficiency in cotton seed meal great enough to produce failure in a relatively short period.

By thus controlling the toxic factor, it is shown that cotton seed injury is not due to a lack of "vitamines" or to deficiency in calcium, sodium, and chlorine.

Heat under various conditions and temperature has been used as a detoxicating agent; moist heat at high temperature being the most satisfactory method up to the present time for rendering cotton seed less harmful. In general the toxic properties are rendered less injurious by heat, but as yet no method has been devised in which meal has been made entirely harmless to all species alike.

The most recent report on gossypol is by Alsberg and Schwartze (1919) who studied its pharmacological action after injection into cats, rabbits, and rats. They found that death from this substance was either due to circulatory failure, pulmonary edema, or cachexia and inanition. However, the action of the isolated gossypol deserves further investigation.

Variations in effects from cotton seed foods

The results of investigators in their studies of cotton seed foods are not constant owing in part to the notable variations in effects upon live stock; even animals of the same species respond at different times with unlike symptoms although they consume similar quantities of the same food. Other difficulties are encountered. The degree of toxicity of cotton seeds depend upon the variety of seed, and upon the climate and soil in which they are grown. And again, the meal, made from the kernels, is greatly altered by the treatment in the process of manu-

facture. There is uncertainty as to the degree of the responsibility of gossypol for the toxicity, as results of investigators differ. All such factors lend difficulty to the study of the effects of cotton seed foods and render the present status of the problem uncertain.[6]

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[6] Since the above was written an experimental investigation of some of the problems involved has been published by Macy, I. G., and Mendel, L. B., Jour. Pharmacol. and Exper. Therap., 1920, xvi, 345.

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DAIRY NOTES

J. W. HENDRICKSON

University of Nebraska, Lincoln, Nebraska

RESIGNATIONS

Prof. J. H. Frandsen, for the past ten years in charge of the department of dairy husbandry of the University of Nebraska, resigned March 1 to become dairy editor and counsellor for the Capper Farm Press of Topeka, Kansas which includes the following publications: Kansas Farmer and Mail and Breeze, Missouri Ruralist, Nebraska Farm Journal, Oklahoma Farmer, Field and Farm, Capper's Farmer. Professor Frandsen will continue his residence at 1401 North 33rd Street, Lincoln, Nebraska.

Before coming to Nebraska, Mr. Frandsen was professor of dairying at the University of Idaho and previous to that time had been engaged in commercial work.

Nebraska's Dairy Department has made very marked progress during the past ten years. It is now housed in what is considered one of the best and most completely equipped buildings in the country. The dairy herd has reached a stage of development in production that has reflected much credit upon the entire institution.

Dr. Roscoe H. Shaw, after fourteen years of service, has resigned as research chemist of the United States Dairy Division in Washington, D. C., to accept the position of chemist and manager of the scientific department of Louis F. Nafis, Inc., of Chicago, manufacturers of scientific glass apparatus for testing milk and its products.

He has held positions on the faculties of the University of Wisconsin (where he was assistant to Dr. Babcock), the Kansas Agricultural College and the University of Nebraska.

Dr. Shaw is the inventor of several tests used in the dairy industry; the best known of these is the Shaw fat test for determining the percentage of fat in butter, others being a special purpose lactometer for use in calculating total solids in milk and a rapid acidity test for grading milk.

DAIRY DIRECTORY

In collecting dairy notes of interest to the readers of the JOURNAL OF DAIRY SCIENCE, a letter was mailed to each department of dairy hus-

bandry in the United States asking for a list of the instructional staff of each institution. From these replies we are pleased to submit the following summary, which is incomplete in total of dairy departments and some of the missing details. Errors may not be always avoided and if any have been made in this summary we will be glad to stand corrected.

Should the readers of the JOURNAL be interested in continuing this as a condensed directory, it may help to know who's who in dairying.

ALABAMA

Experiment Station, Auburn, Alabama

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Eaton, W. H.			B.S.	3
Baker, K. G.			B.S.	2
Burns, F. W.			B.S.	3
Burleson, G. L.			B.S.	3
Lauderdale, A. A.			B.S.	1
Grimes, J. C.			M.S.	1

ARIZONA

College of Agriculture, Tucson, Arizona

Cunningham, W. S.	Professor		B.S.	7
Davis, R. N.	Assistant professor		B.S.	1
Burrows, J. F.	Fellow assistant			2

ARKANSAS

College of Agriculture, Fayetteville, Arkansas

Dvorachek, H. E.	Professor		B.S.A.	6
Mason, R. H.	Assistant Professor		B.S.A.	3

CALIFORNIA

State University Farm, Davis, California

Roadhouse, C. L.	Professor		D.V.M.	4
Turnbow, G. D.	Assistant professor		B.S.A., M.S.	1
Marquardt, J. C.	Instructor		B.S.	4

COLORADO

State Agricultural College, Fort Collins, Colorado

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Morton, Geo. E.	Professor	Head of department animal husbandry and state dairy commissioner	B.S.	
Nevius, H. C.	Deputy dairy commissioner		B.S.	

CONNECTICUT

Connecticut Agricultural College, Storrs, Connecticut

White, G. C.	Professor	Professor of dairying	B.S., A.M.	8
Fisher, R. C.	Professor	Associate professor of dairying	B.S., A.B.	2
Chapman, L. M.	Assistant dairy husbandman		B.S.	3
Campbell, P. A.		Dairy extension	B.S., A.M.	1

DELAWARE

Delaware College and Agricultural Experiment Station, Newark, Delaware

Baker, T. A.	Professor		B.S.	2
Williams, Allan C.	Instructor		B.S.	1
Stretch, B. W.	Stockman and instructor			3

FLORIDA

University of Florida, Gainesville, Florida

Willoughby, C. H.	Professor	Professor of animal husbandry and dairy husbandry	B.S.	9
Scott, John M.		Dairy extension	B.S.	15

GEORGIA

State University, Athens, Georgia

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Jarnagin, M. P.......	Professor	Professor of dairying and animal husbandry	B.S.A.	
Bennett, F. W......	Associate professor		B.S.A.	
Fitch, Frank W.....	Field agent in dairying		B.S.A.	
Marlatt, Leo H.....	Specialist in cheese production			

INDIANA

Purdue University, Lafayette, Indiana

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Gregory, H. W.......	Professor	Chief of Dairying	M.S.	4
Fairchild, L. H......	Assistant professor of dairying		B.S.	2
Lucas, P. S........	Assistant professor		B.S.	1
Fleisher............	Instructor		B.S.	1
Leiendecker, E. H...	Instructor		B.S.	1
Spitzer, Geo......	Associate in chemistry		B.S.	13
Epple, Wm. F........	Assistant in chemistry		B.S.	11
George, C. R........	Associate	Extension	B.S.	6
Canan, R. D.........	Assistant	Dairy extension	B.S.	2

IOWA

Iowa State College, Ames, Iowa

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Mortensen, M.......	Professor	Professor of dairying	B.S.A.	12
Hammer, B. W.......	Professor		B.S.A.	10
Iverson, C. A........	Assistant professor		M.S.	3
Goss, E. F..........	Associate professor		M.S.	2
Wenger, J. C.........	Instructor		B.S.	2
Hinze, F. C..........	Instructor			1
Neasham, R. L......	Instructor		B.S.	1
Pearce, S. J.........	Instructor		M.S.	
Cordes, W. A........	Instructor		M.S.	2

KENTUCKY

University of Kentucky, Lexington, Kentucky

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Hooper, J. J	Professor		M.S.A.	10
Barkman, J. O	Instructor		B.S.	1
Prewitt, E. M		Extension	B.S.	1
Nutter, J. W	Superintendent of dairy			15
Mason, John G	Superintendent official testing		B.S.	1

LOUISIANA

State University, Baton Rouge, Louisiana

Cadwallader, J. M	Professor	Professor of dairying		
Staples, C. H		Dairy extension		
Jefferson, E. C	Assistant	Dairy specialist		

MAINE

University of Maine, Orono, Maine

Corbett, L. S	Professor	Professor of dairying and animal industry		7
Dorsey, L. M	Assistant	Dairy manufacturing		4

MARYLAND

State College, College Park, Maryland

Gamble, James A	Professor	Professor of dairying	M.S.	2

MINNESOTA

University Farm, St. Paul, Minnesota

Eckles, C. H	Professor	Chief of division	M.S., D.Sc.	2
Palmer, L. S	Associate	Dairy chemist	Ph.D.	2
Keithley, J. R	Professor	Dairy products	M.S.	1
Fohrman, M. H	Assistant	Official tester	A.M.	1
Rayburn, A. B	Assistant	Dairy production	B.Sc.	2
Macy, H	Assistant	Dairy bacteriology	B.Sc.	2

MICHIGAN

Michigan Agricultural College, East Lansing, Michigan

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Burnett, J. E	Associate	Dairying	M.S.	5
Goodwin, O. T	Associate	Dairy manufacturing	B.S.	2
Riddell	Assistant	Research	B.S.	7
Howland, Arthur		Field accountant		1
Brownell	Assistant	Research	B.S.	4
Kurtz, Wm. J		Field accountant	B.S.	2
Hint, Elmer B	Superintendent	Official testing	B.S.	1
Kellner, Hilda	Instructor			1

MISSISSIPPI

Mississippi Agricultural College, Agricultural College, Mississippi

Moore, J. S	Professor	Dairying	M.S.	20
Herzer, F. H	Associate	Dairying	B.S.	1
Higgins, L. A		Dairy extension	B.S.	5
Brintnall, Earl		Dairy investigator	B.S.	1
Ferguson, H. C		Dairy extension	B.S.	1
McGowan, W. G		Dairy extension	B.S.	1
Stone, H. C		Dairy herdsman		
Crumpton, Dr. J. W	Manager	Cooperative creamery		
Nichols		Buttermaker	B.S.	1

MISSOURI

University of Missouri, Columbia, Missouri

Ragsdale, A. C	Professor	Dairying	B.S.	5
Sweet, W. W	Associate professor		A.M.	5
Reid, Wm. H. E	Assistant professor		A.M.	2
Brody, S	Assistant professor		M.A.	1
Turner, Chas. W	Instructor		B.S.	2
Nelson, D. H	Assistant		B.S.	

MONTANA

University of Montana, Bozeman, Montana

Martin, G. L	Professor		B.S.A.	6
Tomson, W. E		Extension	B.S.A.	2

MASSACHUSETTS

Agricultural College, Amherst, Massachusetts

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Lockwood, W. P. B.	Professor	Professor of dairying	M.Sc.	12
Judkins, H. F.	Professor		B.Sc.	1
Yaxis, T. G.	Assistant professor		M.Sc.	1
Upton, G. E.	Instructor		B.Sc.	1
Pendleton, H. F.	Instructor		B.Sc.	7 mo.
Sheffield, A.		Superintendent of manufacturing		8 mo.

NEW HAMPSHIRE

Experiment Station, Durham, New Hampshire

Fuller, J. M.	Professor	Dairying	B.S.	4
Depew, H. F.	Assistant professor		B.S.	3½
Huggins, B. E.	Instructor			1½

NEW JERSEY

Agricultural Experiment Station, New Brunswick, New Jersey

Regan, William M.	Professor		M.S.	3
Button, Forrest C.	Assistant professor		B.S.	2
Mead, S. W.	Assistant dairy husbandman		M.S.	
Bartlett, John W.	Extension specialist		B.S.	5
Roberts, Stanley B.	Assistant dairy specialist			1
Robbers, Walter R.	Charge of official testing			2

NEW MEXICO

State College, State College, New Mexico

Cunningham, Omar C.	Professor		B.S.A.	2

NEBRASKA

University of Nebraska, Lincoln, Nebraska

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Hendrickson, J. W...	Assistant professor	Dairy production and acting chairman	M.A.	3
Luithly, J. A........	Assistant professor	Manufacturing	B.Sc.	3
Thompson, B. H.....	Assistant professor	Herd supervisor	B.Sc.	4
Lawritson, M. N. ..	Assistant professor	Extension dairyman	B.Sc.	2
Boehr, J. W.......	Instructor	Official testing	M.Sc.	1

NEVADA

University of Nevada, Reno, Nevada

Scott, V. E....	Professor of dairying			
Nielson, C..........	Herdsman			

NEW YORK

Cornell University, Ithaca, New York

Stocking, W. A......	Professor		B.S.A., M.S.A.	14
Ross, H. E..........	Professor		B.S.A., M.S.A.	14
Troy, H. C..........	Professor		B.S.A.	8
Guthrie, E. S........	Professor		B.A., Ph.D.	12
McInerney, T. J.....	Assistant professor		B.S.A., M.S.A.	10
Jackson, H. C......	Instructor		B.S., M.S.	5
Downs, P. A........	Instructor		B.S.	2
Whiting, W. A.......	Instructor		B.S.	3
Moon, M. P.........	Instructor		A.M.	2
Neville, N. B........	Instructor		B.S.	1
Ayres, W. E.........	Extension instructor			6
Brew, J. D..........	Extension professor		B.S.	1
Price, W. V.........	Assistant		B.S.	1
Smith, L. E.........	Assistant			1
White, W. B........	Assistant		B.S.	
Perry, R. A.........	Instructor		B.S.	2
Robinson, M. B......	Assistant		B.S.	1

NORTH DAKOTA

Agricultural College, Agricultural College, North Dakota

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Dice, James R.	Professor		A.M.	1
Rogers, George B.		Dairyman	B.S.	1

OHIO

State University, Columbus, Ohio

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Erf, Oscar	Professor		B.S.	13
Stoltz, Robert B.	Assistant professor		B.S.	9
McKellip, Ivan	Professor		M.S.	6
Drain, Harry D.	Instructor		B.S.	1
Kochheiser, Don	Instructor		B.S.	2

OKLAHOMA

Agricultural Experiment Station, Stillwater, Oklahoma

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Baer, A. C.	Professor		B.S.A.	4
Burke, A. D.	Assistant professor		M.S.	6 mo.
Doty, Harold E.		Foreman of dairy manufacturing	B.S.	1
Radway, C. W.		Extension dairyman	B.S.	2

OREGON

Oregon Agricultural College, Corvallis, Oregon

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Brandt, Phillip M.	Professor		M.S.	3
Chappell, Vincent D.	Assistant professor		M.S.	3
Jones, Roy C.	Associate professor		B.S.A.	6 mo.
Colman, Howard N.	Instructor		B.S.A.	1
Pine, William B.				2
Fitts, Edward B.	Professor	Extension		6

PENNSYLVANIA

Pennsylvania State College, State College, Pennsylvania

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Borland, A. A	Professor	Professor of dairying	M.S.	6
Bechdel, S. I	Associate professor		M.S.	8
Hunter, C. A.	Associate professor		M.S.	4
Beam, A. L	Assistant professor		M.S.	6
Combs, W. B	Assistant professor		M.S.	2
Swope, W. D	Instructor		B.S.	2
Mitten, J. W	Instructor		B.S.	5
Kloser, M. M	Instructor		B.S.	2
Knutsen, M. H	Instructor		M.S.	2
Simpson, A. C	Instructor		B.S.	3
Williams, P. S	Assistant instructor		B.S.	1

SOUTH CAROLINA

Agricultural College, Clemson College, South Carolina

Fitzpatrick, W. W	Professor		B.S.	4
Cannon, L. B	Assistant professor		B.S.	3

SOUTH DAKOTA

State College, Brookings, South Dakota

Larsen, C	Professor		M.S.	14
Wright, T. H., Jr	Assistant professor		B.S.	4
Jones, Horace M	Instructor		B.S.	3
Johnson, B. L	Analyst		B.S.	3
Culhane, A. F	Instructor		B.S.	2

TENNESSEE

College of Agriculture, Knoxville, Tennessee

Wylie, C. E	Professor		B.S.C., A.M.	4
Hutton, C. A	Dairy specialist extension		B.Sc.A.	6
Clevenger, W. L	Dairy specialist manufacturing		B.Sc.A.	4
Tobey, G. N	Cheese specialist			4

TEXAS

Agricultural College, College Station, Texas

NAME	RANK	DUTIES OR TITLE	DEGREES	YEARS IN POSITION
Pou, R. L.	Professor			1
Clutter, J. A.	Associate professor			2
Darnell, A. L.	Associate professor			8 mo.

VERMONT*

University of Vermont, Burlington, Vermont

Ellenberger, H. B.	Professor		Ph.D.	4
Newlander, J. A.	Instructor		B.S.	1
Hitchcock, J. A.	Extension dairy specialist		B.S.	6 mo.
*Jones, V. R.	Instructor in butter		M.S.	
*Bremer, H. E.	Instructor in testing		B.S.	
*Lynch, A. D.	Instructor in butter		M.S.	
*Frayer, J. M.	Instructor in dairy husbandry		B.S.	
*Gorman, George	Instructor in cheese			
*Dunning, R. G.	Instructor in testing			
*Rand, S. A.	Instructor in mechanics			

WASHINGTON

State College, Pullman, Washington

Woodward, E. G.	Professor		A.M.	3
Phillips, C. A.	Instructor		B.S.	1
Martin, Fred S.	Superintendent of official testing		B.S.	1

WEST VIRGINIA

State University, Morgantown, West Virginia

Anthony, Ernest L.	Professor		B.S.A., M.S.	2
Henderson, Harry O.	Assistant professor		B.S.A., M.S.	1
Perry, Enos J.	Dairy extension specialist		B.S.	1

* The men indicated by the star are special instructors in dairy short courses only.

NEW ANGLES TO THE STARTER-MAKER'S PROBLEM

B. W. HAMMER

Dairy Department, Iowa State College, Ames, Iowa

INTRODUCTION

Since the introduction of starters in 1890 their use has gradually increased until at the present time they are employed in all the important dairy countries of the world in the manufacture of such products as butter, cheese, and fermented milk drinks.

There has been some opposition in the United States during the last few years to the use of starters in the manufacture of butter, due presumably to the exceptional keeping quality of some of the butter made from sweet cream without added starter. In the making of butter of a good and uniform quality with a high aroma and flavor, however, starters have an important place and they seem to be particularly beneficial when the quality of the raw material supplied to the butter-maker is not of a high grade so that the development of a pleasing aroma and flavor becomes very essential. Any disadvantages that starters may have, such as causing a rapid deterioration in butter, seem to be due to high ripening and accordingly can be quite readily overcome. In sections of the country in which the use of starters had become rather uncommon they are again being employed as a means of improving the quality and uniformity of the butter manufactured from gathered cream. It is probable that in spite of the opposition to them on the part of certain individuals starters are more firmly established in the American butter industry than ever before.

THE ACID DEVELOPED IN STARTER

When milk or cream is inoculated with a starter the most significant change that occurs is the development of acid. The acids present in fermented milk or cream can conveniently be divided into two classes as follows: (1) non-volatile, the most

important one being lactic, (2) volatile, acetic acid probably being of the most importance.

Lactic acid has a definite sour taste but is odorless so while it influences the taste of fermented milk or cream it cannot directly be of importance from the standpoint of odor. The volatile acids have a significant influence on the aroma and flavor of fermented milk or cream but they are of little importance alone because the milk constituents have the ability to combine with acids; when however lactic acid is present, the volatile acids are, in part at least, set free and they can then become of direct importance in the aroma and flavor development.

The acids present in cream in addition to influencing the aroma and flavor also influence its churnability so that churning occurs in a shorter time and, in the case of raw cream, is more exhaustive; the non-volatile acids are undoubtedly more important in this connection than the volatile acids since the former are present in the larger amounts.

The volatile acidity of a starter or a lot of ripened cream is very difficult to determine accurately. Hammer and Bailey have used a method consisting of distilling with steam a 250-gram sample of the fermented material, after adding 15 cc. of approximately N/1 H_2SO_4, and titrating the first liter of distillate with N/10 NaOH using phenolphthalein as an indicator; the results are expressed as the number of cubic centimeters of the alkali required. By this method only a portion of the volatile acids is secured and it is probable that the per cent of the total obtained is not always the same but the method yields results that are of significance in studying certain starter problems.

The work recently done on starters has shown that a good well-ripened starter has a more or less definite volatile acidity which amounts to from 30 to 40 when determined according to the method used by Hammer and Bailey. A high volatile acidity, such as that produced by starters, is, however, no assurance that the aroma and flavor are satisfactory. Many very poor starters yield a high volatile acidity and undoubtedly one of the reasons for their poor quality is that they have developed undesirable volatile acids in unusually large amounts. Instead

of simply lacking desirable products they contain some that are decidedly objectionable. Old sour cream generally has a high volatile acidity also, but the aroma and flavor are ordinarily not desirable. It is accordingly evident that while a high volatile acidity is desirable in a starter the volatile acids must be of the right character if the aroma and flavor are to be satisfactory.

ORGANISMS NECESSARY IN A STARTER

Hammer and Bailey, Storch, and Boekhout and Ott de Vries have independently shown that organisms other than Streptococcus lacticus (the common acid-producing organism) are present in starters. Hammer has recently divided the organisms found associated with S. lacticus in the starters studied by him into two types, Streptococcus citrovórus and Streptococcus paracitrovorus; it is entirely possible that associated organisms other than these two definitely characterized types are of importance in certain starters but in the starters studied they were apparently more common than other forms.

The associated organisms are of importance mainly in the production of volatile acids. While S. citrovorus produces very little total acid in milk (usually about 0.25 per cent calculated as lactic) it produces volatile acid from the citric acid normally present and, when grown in combination with S. lacticus, from the lactic acid developed by the latter organism. S. paracitrovorus produces some acid, including lactic, in milk (from 0.39 to 0.77 per cent calculated as lactic) and produces volatile acid from the citric acid and probably also from the lactic acid produced by it or by S. lacticus. The development of volatile acid in a starter depends largely on the activity of the associated organisms since S. lacticus produces only a comparatively small amount.

S. lacticus is nearly always found in starters in larger numbers than the associated organisms and sometimes the latter make up only a very small percentage of the total flora. Occasionally a starter will be found in which S. lacticus is present in smaller numbers than the associated organisms but this is very unusual. In general S. citrovorus lives longer in old acid milk than S. lac-

ticus so there would seem to be little if any danger of the former being lost by the over-ripening of a starter, although the activity of both organisms may be seriously interfered with.

DEVELOPMENT OF STARTER CULTURES

In the development of starter cultures, attempts have frequently been made to use S. lacticus alone. In recent trials at the Iowa Agricultural Experiment Station this organism has been carried in pasteurized milk for many generations but the aroma and flavor development were unsatisfactory and in agreement with this only a low volatile acidity was secured. S. lacticus alone produces acid rapidly enough and in sufficient amounts but the cultures always lack the delicate and pleasing aroma and flavor found in good starters. Although some S. lacticus cultures produce unpleasant odors and flavors, the cultures of this organism are often undesirable because of what they lack rather than because of any definitely objectionable qualities.

When cultures of S. lacticus are carried under creamery conditions they sometimes develop into very good starters due to their becoming contaminated with the associated organisms. One of the commercial cultures at one time contained only organisms of the S. lacticus type but starters obtained it with under practical conditions were often satisfactory because of this contamination.

Starters of a good quality can be prepared quite readily by mixing S. lacticus with one of the associated organisms and carrying the mixture in the usual way. This has been done repeatedly at the Iowa Station and some very good starters have been obtained. On the other hand some of the attempts have not yielded satisfactory cultures, due to the fact that the organisms surviving pasteurization occasionally get a good opportunity for growth during the development of the first or second transfer. The best procedure found was to first grow the bacteria in sterile milk to get a considerable amount of culture of actively growing organisms; it seemed advisable also to inoculate the associated organism at least one day before S. lacticus so that the former would have a good opportunity for growth.

S. citrovorus and S. paracitrovorus and mixtures of the two have been used in combination with S. lacticus in the development of starters, and from the results secured it has been impossible to determine which was the most satisfactory; all of them have given very good starters in some of the trials.

The volatile acidities, after varying numbers of transfers, of 10 starters, 2 made with S. lacticus alone and 8 with mixtures of S. lacticus and one of the associated organisms, are given in table

TABLE 1

Volatile acidities after a number of transfers of S. lacticus alone and mixtures of S. lacticus and associated organisms. Room temperature incubation

STARTER NUMBER	ORGANISMS CONTAINED	TRANSFER NUMBER	AGE OF MILK DISTILLED	TOTAL ACIDITY CALCULATED AS PER CENT LACTIC ACID	VOLATILE ACIDITY*
			days		
1	S. lacticus	28	5	0.96	12.4
2	S. lacticus	30	5	1.02	16.3
3	S. lacticus and S. citrovorus	29	5	1.14	40.7
4	S. lacticus and S. citrovorus	29	4	1.08	44.6
5	S. lacticus and S. paracitrovorus	29	4	1.04	35.3
6	S. lacticus and S. citrovorus	30	4	1.06	46.9
7	S. lacticus and S. citrovorus	13	5	1.14	42.1
8	S. lacticus and S. paracitrovorus	13	5	1.10	32.6
9	S. lacticus and S. citrovorus	8	5	1.13	37.8
10	S. lacticus and S. citrovorus	13	5	1.13	41.7

* As explained under methods the values given represent the cubic centimeters of N/10 NaOH required to neutralize the first 1000 cc. of distillate secured when a 250-gram portion of the milk was distilled with steam after the addition of 15 cc. of approximately N/1 H_2SO_4.

1. From the results presented it is evident that starters made with S. lacticus alone gave a much lower volatile acidity even after a considerable number of transfers than starters made with mixtures of this organism and one of the associated types; the volatile acidities of the mixtures were in general the same as the values secured with good starters. The starters made with S. lacticus alone were decidedly lacking in aroma and flavor while those made with the mixtures had aromas and flavors essentially like a good starter.

Table 2 gives the volatile acidities obtained with 2 starters (one being made with S. lacticus alone and the other with a mixture of S. lacticus and S. citrovorus) after 3, 11, and 15 transfers. The results in general agree with those given in table 1 (although the volatile acidity for the S. lacticus starter is unusually low) and show that the volatile acidity developed tends to be maintained. Table 3 gives the volatile acidities secured with

TABLE 2

Volatile acidity of a starter containing S. lacticus alone compared with that of a starter containing S. lacticus and S. citrovorus. Room temperature incubation

TRANSFER NUMBER	VOLATILE ACIDITY OF STARTER FROM CULTURE CONTAINING	
	S. lacticus alone	S. lacticus and S. citrovorus
3	4.5	36.0
11	4.1	37.0
15	3.1	36.4

TABLE 3

Volatile acidities of commercial cultures carried in sterilized and pasteurized milk through a number of transfers. Room temperature incubation

STARTER FROM MANUFACTURER C						STARTER FROM MANUFACTURER A					
Sterile milk			Pasteurized milk			Sterile milk			Pasteurized milk		
Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity	Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity	Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity	Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity
3	1.00	32.6	7	0.89	33.7	3	0.99	35.3	3	0.83	31.4
6	0.95	35.2	17	1.08	30.8	7	1.01	37.9	6	0.82	24.0
9	1.04	35.8				11	1.05	33.1	8	0.95	26.4
									18	0.93	32.1

2 commercial cultures after varying numbers of transfers in both sterilized and pasteurized milk; the results show that a high volatile acidity was obtained in both types of milk with these cultures through a considerable number of transfers.

Both S. citrovorus and S. paracitrovorus have a definite restraining action on the growth of S. lacticus. This can readily be shown by inoculating either one of the associated organisms

into sterile milk and then later inoculating S. lacticus and at the same time inoculating an equal amount of an S. lacticus culture into sterile milk of the same volume as the first lot. The milk containing only S. lacticus will ordinarily curdle much quicker than the mixture and this must be attributed to the restraining action of the associated organisms on S. lacticus. The inhibitory influence of the associated types can be still more clearly shown if acid determinations are run at various times. It seems reasonable to suppose that this restraining action plays a part in starter-making in maintaining the proper balance between the organisms so that the associated types will not be eliminated by the rapid growth of S. lacticus.

FURTHER PROOF THAT STARTERS ARE NOT PURE CULTURES OF S. LACTICUS

Although the constant presence of associated organisms in good starters and the production of satisfactory starters with the usual volatile acidities from mixtures of S. lacticus and one of the associated organisms but not from S. lacticus alone is very good proof that starters are not pure cultures, other evidence is available.

Lactic acid exists in three forms which are spoken of as *d*, *l*, and *i*, the *i* being a mixture of equal parts of *d* and *l*. S. lacticus ordinarily produces *d* acid and accordingly starters would be expected to contain only *d* lactic acid if they were pure cultures of S. lacticus. However starters have been found to contain *d* acid with some *i* acid so it is evident that organisms other than S. lacticus have been active in a starter along with the S. lacticus type.

A culture of S. lacticus shows practically the same percentage of its total acid present as volatile acid at various acidities while with a starter this percentage increases with an increase in the acidity until at the time the acidity has practically ceased to increase the percentage is much higher than it ever is with a pure culture of S. lacticus. Table 4 gives data along this line for a culture of S. lacticus and for a starter which are illustrative of

the conditions found generally. The variation in the per cent of the total acidity represented by volatile acidity at different times in the development of a starter is good evidence that it is not a pure culture and when this is taken in conjunction with the practically constant percentage for a pure culture of S. lacticus the proof is still more conclusive.

TABLE 4

Relation between volatile and total acidity in a culture of S. lacticus and in a starter. Pasteurized milk, 21°C. incubation

S. LACTICUS				STARTER			
Time elapsed since inoculation	Total acidity calculated as per cent lactic acid	Volatile acidity	Per cent of total acidity represented by volatile acidity	Time elapsed since inoculation	Total acidity calculated as per cent lactic acid	Volatile acidity	Per cent of total acidity represented by volatile acidity
hours				*hours*			
20	0.66	7.5	4.1	15	0 68	7.5	3.9
23	0 72	6.3	3.2	16	0 76	10.0	4.7
39	0.81	8.1	3 6	17	0.81	11.9	5.3
				18	0.84	15.2	6.5
				19	0 86	17.1	7.2
				20	0.88	21.5	8.8
				21	0.91	26.0	10.2
				22	0.93	28.3	11.0
				39	1 10	34.5	11.3

VARIATIONS IN THE VOLATILE ACID PRODUCTION OF STARTERS

With different starters the per cent of the total acidity represented by volatile acid at any given acid content shows considerable variation. This is presumably due to variations in the comparative growth of S. lacticus and the associated type and is one of the reasons why the aroma and flavor of good starters are not always equally satisfactory. In some cases the per cent of the total acidity represented by volatile acidity was found to be about as great at the acidities to which starters are usually ripened (0.7 to 0.9 per cent calculated as lactic acid) as at higher acidities while in other cases it was not. This situation suggests the possibility of developing starters that will have a high volatile acidity at a comparatively low total acidity since this should

result in butter with plenty of aroma and flavor and at the same time with better keeping qualities than if a high total acidity had been secured, since a high acidity probably greatly favors deterioration. The use of S. citrovorus in combination with S. lacticus cultures that have been selected on the basis of their total acid production may make this possible. Preliminary experiments have shown that starters can be prepared that do not quickly show an over-ripe condition as is the case with many starters that are otherwise excellent.

TEMPERATURE OF GROWTH OF THE ASSOCIATED TYPES

S. citrovorus does not grow at 37°C. (98.6°F.) while S. paracitrovorus does. The extreme sensitiveness of S. citrovorus, which is the more common of the associated organisms, to a temperature that ordinarily is very favorable for the growth of organisms is of a great deal of significance to the starter-maker. It indicates that temperatures not properly adjusted may be the cause of unsatisfactory results with starters because they tend to destroy the balance between the organisms which must be maintained if a good flavor and aroma are to be secured. A starter carried at a temperature too high for the growth of S. citrovorus has a flavor and aroma essentially like that of a culture of S. lacticus and also a low volatile acidity.

THE PROBLEM OF MAKING A GOOD STARTER

With definite proof that good starters must contain at least two organisms, the problem of the starter-maker becomes more clearly defined. The carrying of a starter is not a question of making conditions favorable for the growth of one organism and eliminating all others but it is a problem of maintaining a delicate balance between two organisms. The delicate balance is necessary if the aroma and flavor producing materials are to be developed in the proper amounts and the most satisfactory combination. When it is definitely realized that maintaining this balance is a big task and that many factors can influence it the problem of the starter-maker will be on a more understandable basis.

THE RELATION BETWEEN GRADE CLAIMED AND ACTUAL GRADE OF BUTTER PURCHASED IN THE RETAIL MARKET

GEORGE F. REDDISH

Department of Bacteriology, Yale University, New Haven, Connecticut

The prices paid for foodstuffs in the retail markets are justly assumed by the consumer to be based on either quality or food value. On certain kinds of food the differences in food value are too slight to warrant differences in price. In such cases he assumes the price to vary according to quality primarily. Butter is a good example of this group. In the larger wholesale markets butter is generally sold on the basis of grade or quality as determined by score. Such grading systems are made officially by produce exchanges and wholesale "butter boards" in the large cities which are centers of the produce trade. In distributing to the consumer, however, the retailer usually bases his price on what he pays to the jobber or wholesaler rather than upon recognized standards of quality. There thus frequently comes to be some disparity between the price paid by the consumer and the actual quality of the product as determined by score. This condition may again be complicated by the number of dealers interposed between the large produce market and the actual retailer, so that the final selling price sometimes seems to have but little relation to the grade established by the official scorer.

In a series of butter samples collected for another purpose, so great divergence was found between price paid and the score that the collection of further samples were made to include as many brands as possible. Each of these samples was scored by a competent butter scorer, and the price, score and comments of the judge were tabulated with further data resulting from the examination. The contrast of the quality claimed and price paid with the quality found seems sufficiently important to present separately.

In all, 73 samples of butter were purchased in the retail markets of 3 different cities, between June 7 and September 28, 1920. These butters were bought from retailers catering to every class of trade. Of 73 samples of butter bought 60 were claimed by the retailer to be first grade, 6 to be second grade, 2 to be "good butter," 2 to be "process" or "renovated," 1 country butter, and for 2 no grade at all was claimed. The accompanying table gives the sample numbers of the butter, dates of purchase, score, comments of scorer, grade claimed by the retailer, comments of retailer, retail price per pound, and wholesale price per pound of the particular grade or score on the wholesale butter market of New York for the day on which each sample was purchased. Of the 73 samples of butter, 6 scored 93 and above, 14 scored 91 or 92, 22 scored 89 or 90, 17 scored 87 or 88, and 14 scored 86 and below. One of the last group was found "not fit to score."

There is a marked contrast between the grade claimed by the retailer and the actual grade according to the judgment of an expert butter scorer. This contrast was so marked in some cases that very low-grade butter was sold as first-grade by the retailer. The price charged for such butters was always in keeping with the quality claimed, which means that the prices of high-grade butters were paid by the consumer for lower-grade products. In one case a butter claimed to be first grade and sold for 70 cents a pound was characterized as "not fit to score" by the butter scorer.

Not only were the grades claimed by the retailer misleading, but the prices charged did not bear any relation to the wholesale price of each commercial grade as determined by score. Butter which on the wholesale market of New York would sell at 49 cents per pound was sold retail for 70 cents per pound, whereas butter which would sell at $58\frac{1}{2}$ cents per pound wholesale was sold in one market for 65 cents per pound retail. Other examples of this inconsistency are shown in the table. Butters numbered 1 to 46 show a greater divergence in this respect than butters numbered 57 to 73 from a different city, but quite the same or better condition than those from the third city numbered 47 to 56. This is to be expected in view of the fact that the retail

markets of that city are in close contact with wholesale markets and can obtain butter at short notice. In the other two markets, the butter is not so fresh, in most cases, and the quality at time of purchase may be due in part to being held for considerable periods at temperature higher than those of cold storage. However, this fact should not be held responsible for the extreme differences noted in the table, both in the grades claimed and actual grade, and in wholesale and retail prices. The price of a pound of butter in these markets reflects not the quality of the product, but its commercial history supplemented by the efforts of the dealer to assure customers that he is selling high-grade butter.

The consumer has usually no choice but to buy butter offered at the grade claimed, so that frequently very poor butter is paid for at the price of really good butter. The buyer is entitled to be correctly advised of the quality of the product offered. Many purchasers are unable to judge butter correctly in the market, hence must depend upon the recommendation of the seller. Those who are determined to have good butter can only obtain it by extensive "shopping" with great inconvenience and often added expense. Some system of retailing by grade, in which the retail price would bear a proper relation to the wholesale price of each grade, would be the fair way of selling such a commodity as butter. How best to establish such a system of butter marketing is a problem for the industry.

In the table the terminology used for indicating the commercial grades may be a little misleading to the layman. For example, "firsts" are really classified according to butter scorers as second grade, "extras" and "higher scoring" as first grade, and "seconds" as third grade, while "lower grade" is termed "below classification" by the butter scorer. Having this in mind, the differences noted are sharper than would be indicated by the terminology given.

Although the number of samples reported is not large, the condition described is clearly typical of the retail butter trade in the markets studied. The conditions in other cities are probably not

very different from those herein reported. The consumer is manifestly entitled to a more ethical and more equitable relationship between the retail selling prices of the various grades to the wholesale price of the same quality of butter. Whatever its failures and limitations in matters of detail, commercial grading safely places any given sample of butter in its proper class and such placing should be clearly evident in the price of the product at every stage of its commercial history, to insure a square deal to both producer and consumer.

SUMMARY

A comparison of quality claimed and price paid for a series of retail samples of butter showed no correlation with the actual grade and established wholesale prices of butter of the same quality.

Table showing differences between grade claimed and actual grade, and retail and wholesale prices of butter, purchased in the retail markets of three representative cities

Number of butter	Date examined, 1920	Score	Comments of scorer	Grade according to commercial butter grading	Grade claimed by retailer	Comments of retailer (clerk)	Retail price per pound	Wholesale price per pound on New York market Bureau of Markets prices
1	July 8	94	O.K.	Higher scoring	First	First grade	$0.65	$0.58½
2	September 18	94	O.K.	Higher scoring	First	First grade	1.20	.61
3	June 7	93	Slightly oily	Higher scoring	First	Pasteurized creamery butter, highest grade	.75	.57
4	July 30	93	O.K.	Higher scoring	First	First grade	.75	.56
5	July 30	92	O.K.	Extras	First	First grade	.70	.55½
6	August 6	92	Slight foreign flavor	Extras	First	First grade	.70	.54
7	August 6	92	Slightly coarse flavor	Extras	First	Best obtainable	.80	.54
8	September 17	92	O.K.	Extras	First	First grade creamery butter Western	.70	.59
9	July 27	91	Sour flavor	Firsts	Second	Second grade	.64	.54¾
10	August 5	91	Old flavor	Firsts	First	First grade	.70	.53¼
11	August 5	91	Unclean flavor	Firsts	First	First grade	.75	.53¼
12	August 12	91	Slightly off	Firsts	First	First grade creamery butter	.70	.54¼
13	June 7	90	Off flavor	Firsts		Good butter	.65	.53½
14	July 27	90	Sour flavor	Firsts	First	First grade	.70	.54

15	July 29	90	Old taste	Firsts	First	First grade	.75	.54
16	July 29	90	Old taste	Firsts	First	First grade	.75	.54
17	July 30	90	Overripe cream	Firsts	First	First grade	.75	.53
18	September 17	90	Sour flavor	Firsts	First	First grade	.75	.54½
19	September 17	90	Sour flavor	Firsts	First	First grade	.75	.54½
20	June 24	89	Bitter	Firsts	First	Best grade obtainable	.65	.55
21	July 21	89	Oily, mealy, metallic	Firsts	First	First grade, best obtainable	.70	.54½
22	July 27	89	Slightly bitter, high moisture	Firsts	First	First grade Quality butter	.70	.53
23	July 30	89	Poor cream	Firsts	First	First grade	.73	.52
24	August 5	89	Old cream flavor	Firsts	Second	Second grade	.65	.51¾
25	August 6	89	Old cream flavor	Firsts	Second	Second grade	.68	.51¾
26	August 6	89	Cheesy	Firsts	First	First grade	.75	.51¾
27	August 12	89	Unclean, sour	Firsts	First	First grade	.65	.52½
28	September 17	89	Unclean	Firsts	First	First grade	.75	.53
29	June 7	88	Sour	Firsts	First	Highest grade creamery butter	.70	.51
30	July 27	88	High H_2O, poor flavor	Firsts	First	First grade, excellent	.66	.52
31	July 27	88	High H_2O, poor flavor	Firsts		"Best we have"	.75	.52
32	July 27	88	Slightly bitter, high moisture	Firsts	First	First grade	.66	.52
33	August 6	88	Sour and unclean	Firsts	First	First grade	.70	.51

Table showing differences between grade claimed, etc.—Continued

NUMBER OF BUTTER	DATE EXAMINED, 1920	SCORE	COMMENTS OF SCORER	GRADE ACCORDING TO COMMERCIAL BUTTER GRADING	GRADE CLAIMED BY RETAILER	COMMENTS OF RETAILER (CLERK)	RETAIL PRICE PER POUND	WHOLESALE PRICE PER POUND ON NEW YORK MARKET BUREAU OF MARKETS PRICES
34	August 5	87	Very poor, musty	Seconds	First	First grade	.70	.50
35	August 5	87	Old and sour	Seconds	First	First grade	.70	.50
36	August 6	87	Sour and unclean	Seconds		Good grade	.60	.50
37	July 27	86	Bitter	Seconds	First	First grade	.65	.51
38	July 27	86	Bitter	Seconds	First	First grade	.64	.51
39	August 5	86	Sour or musty	Seconds	Second	Second grade	.62	.49
40	August 5	86	Musty and cheesy	Seconds	First	First grade	.55	.49
41	August 12	85	Very cheesy	State Dairy Common to fair		Creamery butter	.65	.49
42	July 29	84	Moldy	Seconds		(None claimed)	.63	.50½
43	August 5	84	Cheesy and old	Seconds	First	First grade	.60	.49
44	August 5	83	Very poor, old and cheesy	Seconds		Renovated	.60	.49
45	August 5	83	Very cheesy	Seconds		Process	.60	.49
46	August 5	0	Not fit for score	Lower grade	First	First grade	.70	.49
47	September 7	91	O.K.	Firsts	First	First grade	.70	.56½
48	September 8	89	Slightly bitter	Firsts	First	First grade	.65	.53
49	September 7	88	Flat, neutralized	Firsts	First	Excellent butter	.70	.51
50	September 7	87½	Slightly off flavor, low in salt	Seconds	First	First grade	.65	.50

51	September 7	87	High acid, cheesy curdy	Seconds			.65	.50
52	September 8	87	Flat, high salt	Seconds	First	First grade	.65	.50½
53	September 8	86	Old, stale, musty	Seconds	First	First grade	.65	.49
54	September 7	85	Flat, high salt	Seconds	First	Best butter	.65	.49
55	September 8	84	Cheesy, high salt	Seconds	First	First grade	.65	.49
56	September 7	80	Curdy, rank rancid	Lower grade	First	First grade	.65	.49
57	September 27	94	Danish butter	Higher scoring	First	Best butter we can get	.70	.63
58	September 28	93	Sweet, clean, Danish	Higher scoring	First	Finest creamery butter	.63	.62
59	September 27	92		Extras	First	Best butter	.70	.62
60	September 28	92		Extras	First	Best creamery butter	.70	.61
61	September 28	92	Sweet, clean, unsalted	Extras	First	Best butter, sweet	.76	.61
62	September 28	91	Slightly woody flavor	Firsts	First	Best butter	.76	.60
63	September 28	91	Slightly oily flavor	Firsts	First	First grade	.75	.60
64	September 27	90	Acidy	Firsts	First	First grade	.70	.58
65	September 28	90	Oily	Firsts	First	First grade	.69	.57
66	September 28	89	Lardy	Firsts	First	First grade	.67	.53½
67	September 28	89	Oily flavor	Firsts	First	Best butter	.77	.53½
68	September 28	89	Old flavor	Firsts	Second	Second grade	.67	.53½
69	September 27	88	Sour	Firsts	First	Finest butter	.70	.52½
70	September 27	88	Old, stale, curdy	Firsts	First	Best butter	.70	.52½
71	September 28	88	Slightly fishy	Firsts	First	Best obtainable	.72	.52
72	September 28	88	Foreign flavor, woody	Firsts	First	First grade	.67	.52
73	September 28	87	Strong, slight rancid	Seconds	Second	Second grade	.67	.50½

THE RELATION OF ACIDITY TO THE COAGULATION TEMPERATURE OF EVAPORATED MILK

L. A. ROGERS, E. F. DEYSHER, AND F. R. EVANS

Research Laboratories of the Dairy Division, United States Department of Agriculture

INTRODUCTION

In the condensed milk industry, it has always been recognized that there is a definite relation between the acidity of the milk and the temperature at which the milk coagulates in sterilization. The usual conception of the acidity of evaporated milk is that the acidity is increased in the same ratio as the solids of the milk. In other words, if fresh milk in which the titration indicated an acid content equivalent to 0.17 per cent lactic acid were concentrated in the ratio of 2.25 to 1 the resulting product would contain acid equivalent to 2.25×0.17 or 0.38 per cent. It has also been assumed that the titration of the fresh milk against a standard alkali solution would given an indication of the action of the evaporated milk under the high heat of the sterilizing process.

The development of our knowledge of the chemistry of milk in recent years has made it clear that the acid relations of the the milk are not as simple as these assumptions would indicate. It is now well established that the true acidity of a complex fluid like milk cannot be determined by titrating with alkali. This is due primarily to the fact that constituents of the milk other than the acids combine with the alkali and are titrated as acid.

Rice (1) has pointed out that the casein and the phosphates, both of which combine with alkali, are subject to sufficient variation to cause in some instances an apparent high acidity in fresh milk. A recent paper from this laboratory (2) points out that the coagulation temperature of evaporated milk is not necessarily correlated with the titratable acidity of the fresh milk.

It still remains to be determined just how much relation there is between the true acidity of the milk as measured by determin-

ing the hydrogen-ion concentration and the temperature at which the evaporated milk will curdle. Sommer and Hart (3) have shown that the time required to coagulate fresh milk from individual cows at a fixed temperature has no definite relation to its hydrogen-ion concentration. Although they show that the coagulating time is increased by changing the concentration by dilution with water, we feel that it would be unsafe to go very far in applying these results to evaporated milk. Not only is the tendency of the milk to curdle greatly increased by the concentration of the solids, but it has also been exposed to the high temperature of the forewarmer and the prolonged heating and agitation in the pan. It is well known among condensers that the forewarming has an effect on the coagulating temperature. In table 1 are given the results of some determinations on the relative coagulating temperature of fresh milk and of the same milk after evaporating to a uniform concentration of solids-not-fat of 17.7 per cent. These samples were mixed herd milks from single farms and were obtained through the courtesy of a local milk dealer. The coagulation point of the whole milk was determined by heating the milk in sealed tubes immersed in an oil bath held at a constant temperature. Since the tubes held only about 5 cc. no allowance was made for time required to bring them to the temperature of the bath.

Tubes were exposed for twenty minutes to a series of temperatures differing by 3°. The determinations on the raw milk were made just before condensing. The milk was condensed in large flasks, following as closely as possible the procedure of the condensery, including forewarming at about 95°C. The evaporated milk was usually held over night at a temperature near zero and the determination of the coagulating point made the following day.

The results on 14 samples are shown in table 1 and figure 1, in which the samples are arranged in the order of the coagulating temperature of the raw milk. It is not to be expected that the mixed herd milk would show the wide variation in the coagulating temperature found by Sommer and Hart for the milk of individual cows. It is evident from these results, first, that the variation

in the coagulating temperature of mixed milk is too small to be of value; and second, that there is no consistent relation between the narrow variation which does occur in the coagulting temperature of the mixed raw milk and that of the same milk after evaporation.

It is possible that a more accurate method of determining the coagulating point would reduce the great variation observed in some of these samples, but it is very doubtful if even this would make it safe to predict the coagulation temperature of evaporated milk from results obtained on raw milk.

TABLE 1

Relation of coagulation temperature of raw milk to coagulation temperature of milk after evaporation

LABORATORY NUMBER	RAW MILK COAGULATION TEMPERATURE, 20 MINUTE EXPOSURE		EVAPORATED MILK COAGULATION TEMPERATURE, 20 MINUTE EXPOSURE	
	°C.	°F.	°C.	°F.
673	137	278.6	128	262.4
674	134	273.2	125	257.0
685	136	276.8	112	233.6
689	137	278.6	115	239.0
684	137	278.6	131	267.8
672	140	284.0	119	246.2
670	140	284.0	113	235.4
664	140	284.0	107	224.6
663	140	284.0	105	221.0
691	141	285.8	130	266.0
688	142	287.6	133	271.4
671	143	289.4	122	251.6
669	143	289.4	125	257.0
667	146	294.8	113	235.4

In the paper quoted, Sommer and Hart emphasize the importance of the mineral constituents of the milk in maintaining the stability of the casein. Their views on this question are summarized in the following paragraph:

From the data, we see that the calcium and magnesium are balanced by the phosphates and citrates of the milk practically in gram-equivalent amounts. The sodium and potassium chlorides in the concentrations present do not have any marked influence on the coagulating point, so that the balance of the four constituents, calcium, magnesium,

citrates, and phosphates, largely determine whether a milk will coagulate or not. If calcium and magnesium are in excess, the milk will coagulate on heating. If calcium and magnesium are properly balanced with the phosphates and citrates the optimum stability obtains. If phosphates and citrates are in excess, coagulation will also result.

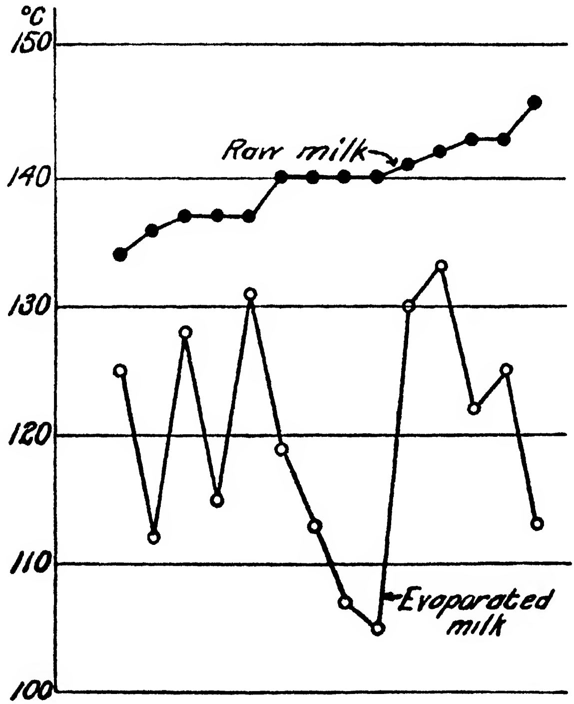

FIG. 1. COMPARISON OF THE COAGULATING TEMPERATURES OF RAW AND EVAPORATED MILK

They consider that the composition of the milk salts is the main factor in determining the coagulating point of fresh milk, and that the hydrogen-ion concentration, though only a minor factor in the coagulation of fresh milks, may become an important one in commercial milk. If we accept the conclusions reached in this paper, there still remain unanswered a number of questions of great interest to the manufacturer of evaporated milk. If we knew the relation of the acids to bases in a batch of milk, could

we predict the coagulation temperature of this milk after evaporation? Or, to put it on a still more practical basis, if it were possible to determine the acid-base ratio of the milk from individual farms as it comes to the factory, would it be possible to reject the milk which lowers the coagulating point of the finished product below the limit of safe sterilization? To what extent is the true acidity of the milk a factor in determining the coagulating temperature of the evaporated milk?

It should be kept in mind that the results given in Sommer and Hart's paper were obtained, as the authors are careful to point out, on fresh milk from individual cows. We are now concerned with the mixed milk from a number of cows and with the coagulation of evaporated milk rather than the untreated milk. In investigating these problems, we have compared the hydrogen-ion concentration and the acid-base ratio of a series of representative samples of milk with the coagulation temperature of these milks after evaporation. This has been supplemented by a series of experiments in which the hydrogen-ion concentration has been varied by the addition of acid or by the growth of acid-forming bacteria.

EXPERIMENTAL

The relation of the acid-base ratio to the coagulation temperature of evaporated milk

The milk used in this part of the investigation was obtained from a local dairy. Each sample represents mixed milk from a single farm and presumably was milked on the previous evening and the morning of the day it arrived at the dairy. Samples were brought to the laboratory before noon and, after taking samples for the chemical determinations, were held on ice until the following morning. The evaporation was done in flasks under a vacuum of 26 to 28 inches. Unless otherwise stated, the milk was brought to 95°C. in steam bath and drawn slowly into the flasks without holding. The amount of water which it was necessary to remove to bring the solids-not-fat to a concentration of 17.7 per cent was calculated from the solids-not-fat determination on the raw milk. The amount of water removed was

determined roughly on the graduated receiver of the distillation apparatus and more accurately by removing the boiling flask and weighing back on a balance accurate to 10 grams. In this way all samples were brought to a uniform concentration of solids-not-fat, although there was necessarily considerable variation in the fat content. After cooling the finished milk, it was sealed in baby-size cans and held over night in ice water.

TABLE 2

Relation of excess base and hydrogen-ion concentration to coagulation temperature. Samples arranged in order of coagulation temperature

NUMBER OF SAMPLE	EXCESS BASE OVER ACIDS	pH OF EVAPORATED MILK	COAGULATION, 30 MINUTES EXPOSURE IN STERILIZER		NUMBER OF SAMPLE	EXCESS BASE OVER ACIDS	pH OF EVAPORATED MILK	COAGULATION, 30 MINUTES EXPOSURE IN STERILIZER	
			°C.	°F				°C	°F.
667*	0.69	6.26	100	212.0	692	0.57	6 24	118	244.4
735	0.49		100	212.0	701	0.38		119	246.2
664*	0.77	6 16	102	215.6	673	0.51	6.34	119	246.2
718	0.13	6.24	104	219.2	696	0.43	6.29	119	246.2
663*	0.80	6.27	105	221.0	669	0.70		119	246.2
685	0.53	6.17	108	226.4	731	0 51	6.31	119	246 2
672	0.51	6.26	110	230 0	734		6 23	119	246.2
732	0.51	6 27	110	230.0	691	0.46	6 27	119	246 2
670	0.42	6 26	110	230.0	720	0 53		119	246 2
689	0 60	6.13	110	230 0	721	0 53		119	246.2
739	0.43		113	235 4	688	0 56	6.34	122	251.6
668	0.60	6.39	115	239.0	733		6.27	122	251.6
714	0.74		116	240.8	674	0 51	6 33	122	251.6
695	0 54	6.38	116	240.8	684	0 35	6.26	122	251.6
671	0.35	6.31	116	240.8	726	0.61	6 28	122	251.6

* Forewarmed ten minutes at 75°C. (167° F.).

The sterilization was done in a pilot sterilizer on the day following the evaporation. The cans were kept in motion during sterilization and fifteen minutes were allowed to bring the cans to the sterilizing temperature which was maintained for thirty minutes. The sterilizing temperature was increased by steps of 2° or 3° until the minimum temperature was found at which a curd was formed which did not disappear on shaking.

Calcium, magnesium, citric acid, and phosphates were determined in the raw milk. From this was calculated the excess of

base over acid as outlined in Sommer and Hart's paper. These results are given in table 2 and for convenience of comparison are plotted in figure 2 with the samples arranged in the order of excess of base over acids. If there is a direct relation between the acid-base ratio and the coagulation temperature of the evaporated milk, there should be higher coagulation temperature as the excess of base over acid approaches zero. In these samples the variation in the coagulation temperature is so great that no exact curve can be traced. Although there may be a

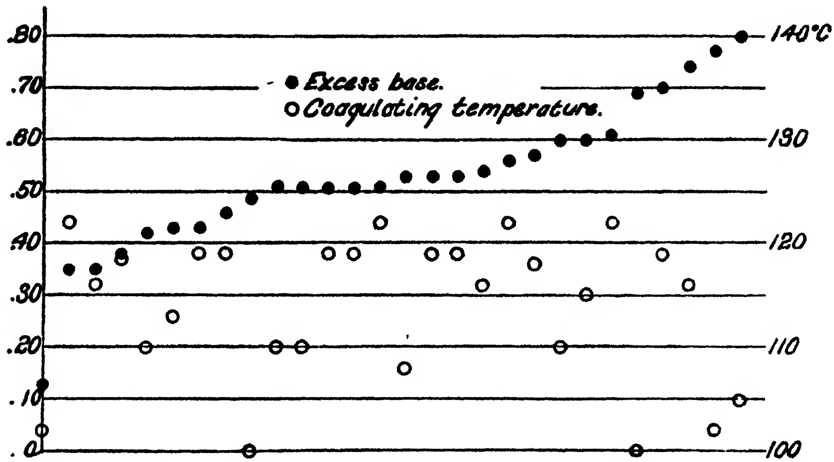

FIG. 2. THE RELATION OF EXCESS OF BASE OVER ACID IN RAW MILK TO THE COAGULATING TEMPFRATURE OF EVAPORATED MILK

slight downward tendency as the excess of base increases,thereare so many exceptions that no definite conclusions can be drawn. This lack of correlation would be even more marked if samples 667, 664 and 663 were omitted. These milks were among those having a large excess of base over acid and all coagulated at 105° or lower. An examination of the records showed that these samples were forewarmed ten minutes at 75°C., rather than at 95°C., the usual procedure. Results which will be quoted later in this paper indicate that if these three samples had been heated to 95°C. the coagulating temperature would have been materially higher.

These results do not necessarily mean that the composition of the salts of milk is without influence on the temperature at which the evaporated milk curdles. It is evident, however, that whatever influence the acid-base ratio may have, it is usually obscured by other factors.

The hypothesis that the stability of the casein is, in part at least, dependent on the interrelation of the mineral constituents of the milk is supported by the effect on the coagulating temperature, of heating the milk before condensing. It seems to be a matter of general knowledge in the industry that the coagulating temperature can be raised by high or prolonged forewarming temperature.

TABLE 3

Influence of forewarming temperature on coagulation in sterilization

EXPERIMENT NUMBER	BATCH NUMBER	FOREWARMING TEMPERATURE		FOREWARMING TIME	COAGULATION TEMPERATURE	
		°C.	°F.		°C.	°F.
				minutes		
1	782	*	*		95	203.0
	783	95	203	10	125	257.0
2	786	95	203	Not held	119	246.2
	785	95	203	10	122	251.6
	784	95	203	20	125	257.0

* No forewarming.

That new equilibria are formed when milk is heated is shown by the fact that the hydrogen-ion of heated milk is always higher than that of the corresponding raw milk. Milroy (4) has shown that heating milk to high temperatures precipitates part of the calcium, and Sommer and Hart suggest that this reaction probably explains the increased stability brought about by the high forewarming. The effect of forewarming to 95°C. is usually to raise the coagulating temperature of the evaporated milk by 15° to 30°C. This is shown in table 3.

The influence of the time factor is shown in the last experiment given in this table, in which the coaglating temperature of 119°C., obtained when the milk was heated to 95°C., was raised to 122°C.

by holding at 95°C. ten minutes, and to 125°C. by holding twenty minutes. These results would indicate that while the major part of the calcium precipitation was brought about by the heating to 95°C. there was a continued small precipitation when the milk was maintained at this temperature.

Influence of the hydrogen-ion concentration on the coagulating temperature

It is very difficult to separate the effect of the hydrogen-ion concentration from that of the composition of the salts of the milk. Any change in the latter, by raising or lowering the buffer action, changes the hydrogen-ion concentration; and the low coagulating point obtained by altering the acid-base ratio may be due to the disturbance in the chemical union through which the minerals stabilize the casein, or to an increase in the hydrogen-ions.

The relation of the hydrogen-ion concentration of normal herd milk to heat coagulation after condensing was determined on the same lots of milk as were used for the acid-base investigation, and the results are also given in table 2. The hydrogen-ion determinations were made electrometrically and are expressed in terms of Sörensen's scale; these terms, it should be remembered, vary inversely as the hydrogen-ion concentration.

When milk is concentrated there is a decrease in the pH; in other words an increase in the acidity. This change is very uniform, as may be seen in table 4. The decrease in 17 samples averages very closely 0.25. This excepts sample 695, which may have been an error or may possibly have been due to rapid growth of bacteria in the raw milk before the determination could be completed. It was evident from these results that the pH of the evaporated could be used as satisfactorily as that of the raw milk for this investigation.

It will be noted that there is a very considerable variation in the pH of the different samples. In order to bring out such relation as may exist between this variation in the pH and the coagulating point, the results tabulated in table 2 are shown graphically in figure 3. In this the samples are arranged in

the order of the pH values with the scale reversed so that the dots represent a series of samples of decreasing acidity.

TABLE 4

Change in hydrogen-ion concentration in condensing

NUMBER OF SAMPLE	pH OF RAW MILK	pH OF EVAPORATED BEFORE STERILIZING	DECREASE IN pH
663	6.50	6.27	0.23
664	6.45	6.16	0.27
667	6.55	6.26	0.29
668	6.60	6.39	0.21
669	6.58	6.36	0.22
670	6.50	6.26	0 24
671	6.57	6.31	0.26
672	6.49	6.26	0.23
673	6.58	6.34	0.24
674	6.57	6.33	0.24
684	6.50	6.26	0.24
685	6.41	6.17	0.24
689	6.36	6.13	0.23
691	6.57	6.27	0.30
692	6.56	6.24	0.22
695	6.43	6.38	0.05
696	6.54	6.29	0.25
718	6.52	6.24	0.28

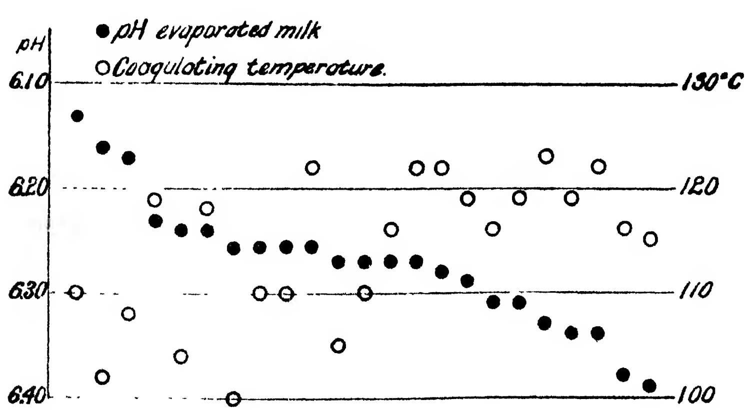

FIG. 3. THE RELATION OF HYDROGEN-ION CONCENTRATION TO THE COAGULATING TEMPERATURE OF EVAPORATED MILK

The coagulating temperature for each sample is shown by a circle directly under the dot representing the pH of that milk before sterilization. If there is a direct relation between the acidity as measured by the pH determination and the coagulation temperature, the latter should be higher as the pH curve goes down.

We find that while there is a general tendency upward in the coagulating temperatures, the variation is so great that even an approximate curve cannot be drawn. Nor is it possible to draw a line in the pH curve below which the milk may be expected to curdle at a low temperature and above which it may be sterilized without fear of curdling. It is true that all of the samples curdling below 115°C. had a pH of 6.27 or lower, but the variation is so great that no rule can be established, at least not from the data now available.

This is particularly evident in the four samples with a pH of 6.27, coagulating respectively at 105°, 110°, 119° and 122°C. Sample 663, coagulating at 105°, should be excluded on account of its low forewarming temperature. A similar variation is found in the four samples with a pH of 6.26.

It should not be inferred from this that the hydrogen-ion concentration of the milk is not a factor in the heat coagulation of the milk. On the contrary it is to be expected that it would have a decided influence in determining the temperature of coagulation, and experimental evidence shows that this is even more true of evaporated than it is of raw milk.

In an experiment, the results of which are given in table 5, the raw milk with a pH of 6.45 curdled in sealed tubes in an oil bath when exposed twenty-minutes to a temperature of 140°C. When the acidity was increased by addition of lactic acid to a pH of 6.29 the coagulation point was reduced only 3°. When this milk was condensed to a concentration of 14 per cent solids-not-fat, the coagulation point was reduced to 135°C. By the addition of sufficient acid to bring the pH to 6.16, a change of 0.20, the coagulation point was reduced 25°C. A change of 0.24 in the pH of the portion condensed to 18 per cent solids not fat reduced the coagulation point 38°C. and an equal change was produced in the 22 per cent milk by a change of 0.67 in the pH.

TABLE 5

Effect of changes in hydrogen-ion concentration in milks of varying concentration. Hydrogen-ion concentration increased by the addition of acid

CONCENTRATION SOLIDS NOT FAT	pH	COAGULATION TEMPERATURE, 20 MINUTES EXPOSURE		CHANGE IN pH	CHANGE IN COAGULATION TEMPERATURE	
		°C.	°F		°C.	°F.
per cent						
Normal	6.45	140	284.0			
	6.29	137	278.6	0.16	3	5.4
14	6.36	135	275.0			
	6.16	110	230.0	0.20	25	45.0
18	6.30	133	271.4			
	6.06	95	203.0	0.24	38	68.4
22	6.16	125	257.0			
	6.09	87	188.6	0.07	38	68.4

TABLE 6

Effect of changes in hydrogen-ion concentration brought about by the growth of bacteria on the coagulation of the evaporated milk

NUMBER OF SAMPLE	INOCULATION	INCUBATION TIME	pH EVAPORATED	COAGULATING TEMPERATURE, 30 MINUTES EXPOSURE	
				°C	°F
		hours			
726	None	4	6.28	122	251.6
727	Lactic	4	6.17	106	222.8
731	None	4	6.31	119	246.2
732	Lactic	4	6.27	110	230.0
733	None	2½	6.27	122	251.6
734	Lactic	2½	6.23	119	246.2
738	None	2	6.24	113	235.4
737	Lactic	2	6.21	110	230.0
736	Lactic	3	6.18	107	224.6
745	None	2½	6.24	119	246.2
744	Lactic	2½	6.19	113	235.4
743	Lactic	2½	6.12	107	224.6

The results shown in table 6, in which the change in acidity was produced in the raw milk by the growth of acid-producing bacteria, are more comparable with factory conditions. We find that changes in the pH as small as 0.03 or 0.04 have a very appreciable effect on the coagulation temperature.

The results of an experiment designed to show the relation between the growth of bacteria, the change in acidity, and the coagulation point are shown in table 7. In this experiment 220 pounds of fresh whole milk was inoculated with 200 cc. of an active lactic culture in milk. After inoculation, the milk was warmed to 30°C. (86°F.) and held at room temperature. Bacteriological plates, using milk powder agar, were made at one-hour intervals. Immediately after inoculating, one-third of the milk was

TABLE 7

Influence of the growth of acid-forming bacteria on the coagulating temperature

AGE	BACTERIA IN RAW MILK		TITRATABLE ACIDITY	pH		COAGULATION TEMPERATURE	
	Total	Lactic		Raw	Evaporated	°C.	°F.
hours	*per cc.*	*per cc.*	*per cent*				
0	1,140,000	790,000	0.17	6.57	6.33	119	246.2
1	6,200,000	3,600,000					
2	20,950,000	13,950,000					
3	47,500,000	30,500,000	0.175	6.51	6.27	113	235.4
4½	96,000,000	53,500,000	0.207	6.43	6.21	110	230.0

forewarmed ten minutes at 95°C. (203°F.) and condensed in the laboratory pan to a concentration of 17.7 per cent solids not fat. This milk coagulated in the pilot sterilizer at 119°C. (246.2°F.).

At the end of three hours there was a distinct change in the hydrogen-ion concentration which could also be detected by careful titration with 10/N alkali.

Half of the milk remaining was condensed as before, duplicating the procedure and concentration as closely as possible. The slight change in acidity in this milk was sufficient to reduce the coagulating temperature to a point which would make the sterilization uncertain. The third portion of the milk was condensed at the end of four and a half hours, when the acidity had changed very appreciably and the coagulating point was so low that the milk could not be sterilized.

CONCLUSIONS

In the light of the results obtained in this investigation, we are unable to conclude that under commercial conditions there is any very definite relation between the acid-base ratio of the raw milk and the coagulating point of the evaporated milk. That the relation established by Sommer and Hart for fresh milk from individual cows does not hold for these conditions is probably due partly to the readjustment of this ratio brought about by a precipitation of a part of the calcium in the forewarming process and partly to the obscuring effect of other factors.

It is very evident that exact information in regard to the relations of the mineral constituents of the milk would be of little value in determining its suitability for condensing purposes.

Notwithstanding the generally accepted views as to the value of grading milk on the basis of its titratable acidity, the results obtained by determining the hydrogen-ion concentration electrometrically do not indicate that the relation between the acidity of the fresh milk and the coagulating point after it is evaporated is sufficiently uniform to make it of much value in grading milk.

This is evidently because the hydrogen-ion concentration giving the maximum stability to the casein varies with the composition of the milk. The results show that any increase from the normal hydrogen-ion concentration of milk causes a distinct reduction in the coagulation temperature after evaporation, although the final hydrogen-ion concentration may still be considerably under that of another sample which is comparatively stable. For this reason it will be difficult if not impossible to draw any definite limit in hydrogen-ion concentration above which the milk would be unsuitable for evaporating.

The essential fact which must be established in this connection is not the mere hydrogen-ion concentration of the milk, but whether this has been changed from the normal of that particular milk.

It is possible that when the milk from a large number of cows is mixed the effect of variation in composition on the hydrogen-

ion concentration would be less evident and any increase in acidity due to the growth of bacteria could be detected. Thus a titratable acidity of 0.19 or 0.20 per cent in a large batch of milk would almost certainly indicate an increase in acidity from the normal due to fermentation. The same titration in the milk from a small herd would be less conclusive; the acidity of milk from individual animals is subject to considerable variation and the value of the acidity determination becomes very questionable.

In any case it is evident that while the effect of increased acidity brought about by bacteria has a marked effect on the coagulating point, there are other factors of equal or of even greater importance which may obscure the effect of increased acidity. One of these factors is now under investigation and will be the subject of another paper.

SUMMARY

The variation in the coagulation temperature of mixed herd milk is comparatively small and has little relation to the coagulating temperature of the same milk after evaporation. Consequently the temperature at which evaporated milk made from the mixed milk of a number of cows will curdle cannot be predicted with any accuracy by determining the coagulating temperature of the raw milk.

The interrelation of the constituents of the ash of the milk, which has been shown to be a factor in determining the coagulating point of fresh milk from individual cows, is only a minor factor in determining the coagulating temperature of evaporated milk. This is partly due to the rearrangement of the acid-base relation in the condensing process, and partly to the obscuring effect of other factors, which in the mixed milk from many cows become of much greater significance.

The effect of high forewarming in raising the coagulating temperature of evaporated milk is evidently due to the precipitation of part of the calcium. Forewarming temperatures much below 95°C. (203°F.) have little effect on the coagulating temperature.

The effect of high forewarming may be increased by prolonging the heating.

There is no very definite relation between the coagulating temperature of evaporated milk and the true acidity, as measured by determining the hydrogen-ion concentration of the milk before sterilization. There is a comparatively wide limit within which the hydrogen-ion concentration may vary without influencing the coagulating temperature.

A very small increase in the acidity from the normal for that particular milk will cause a distinct lowering of the coagulating temperature of the evaporated milk.

Other factors which have not yet been fully investigated have an important influence on the coagulating temperature without appreciably changing the acidity.

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THE USE OF COTTONSEED MEAL TO INCREASE THE PERCENTAGE OF FAT IN MILK

ANDREW C. McCANDLISH

Iowa Agricultural Experiment Station, Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa

A high level of milk and butterfat production indicates generally economy of production, a factor of vital importance. As a consequence of this it is deemed essential at the present time that purebred dairy cattle must be backed by good records. The outcome is that large numbers of cows are tested every year for complete lactations or periods of shorter lengths and the aim in most cases is to get the highest record possible.

It has always been admitted that the amount and nature of the feed consumed by a cow would have a considerable influence on her yield of milk and butterfat though it has generally been believed that the percentage of butterfat present in the milk could not be altered to any great degree by feeding. With the rapid development of testing during the last few years every possible effort has been put forward by men to increase the fat content of the milk by feeding and as a consequence it is a byword among dairymen that cottonseed meal, and a few other feeds will influence the fat percentage in the milk.

This factor is of greatest importance with cows on yearly test as it affects all the breeds of dairy cattle and a high fat content obtained during the two days that the tester is on the farm is used, with the total milk yield for the month, to calculate the monthly fat yield. Consequently, in outlining the work reported here, consideration was given to yearly record work rather than to testing for shorter periods. . The work outlined here is only preliminary and much study is yet needed by this problem.

RÉSUMÉ OF PREVIOUS WORK

In reviewing the literature on this subject it was believed best to also review the work on other feeds of high protein content

TABLE 1

Digestible nutrients in feeds considered; after Henry and Morrison (19)

FEED	CRUDE PROTEIN	CARBO-HYDRATES	FAT	TOTAL
	per cent	*per cent*	*per cent*	*per cent*
Peanut meal	42.8	20.4	7.2	79.4
Soybean meal	38.1	33.9	5.0	83.2
Cottonseed meal	37.0	21.8	8.6	78.2
Linseed oil meal (O. P.)	30.2	32.6	6.7	77.9
Gluten meal	30.2	43.9	4.4	84.0
Gluten feed	21.6	51.9	3.2	80.7
Flaxseed meal	20.6	17.0	29.0	102.8
Coconut meal	18.8	42.0	8.1	79.0
Germ oil meal	16.5	42.6	10.4	82.5

TABLE 2

Changes in fat percentage produced by peanut meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures	Backhaus (2), Juretschke (29), Kellner (34), Kochs and Ramm (32), Ramm (47), Ramm and Moller (49), Ramm, Momsen and Schumacher (50), Vieth (56)	3	2	3
Cottonseed meal	Dunlop and Bailey (11)			1
Linseed meal	Ramm, Momsen and Schumacher (50)			1
Gluten meal	Ramm (48)	1		
Coconut meal	Heirnich (18), Lund (40)			2

TABLE 3

Changes in fat percentage produced by soybean meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures	Hannson (16), Lindsey (35), Lindsey, Holland and Smith (36)		2	1
Cottonseed meal	Brooks (4)			2
Linseed meal	Hansen (17), de Vries (57)			2
Coconut meal	Lund (40)			1

which might under certain conditions give the same results as cottonseed meal. The references to work with the feeds of high protein content are extremely numerous though only a limited number bear on the problem in hand, and very few of these directly. It is quite noticeable that most of the work of this character was done at a relatively early date and few references to it are to be found in the literature of the last fifteen or twenty years.

TABLE 4

Changes in fat percentage produced by cottonseed meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures.	Backhaus (2), Collier (6), Crowther (9), Curtiss (10), Hannson (16), Hofmann and Hansen (24), Hunt (25), Jordon (28) Lane (34), Lindsey (35), Lindsey et al (38), Lloyd (39), Michaels (41), Milburn and Richardson (42), Moore (43, 44), Porter (45), Ramm (47), Speir (52, 53)	10	10	2
Peanut meal	Dunlop and Bailey (11)	1		
Soybean meal	Brooks (4), Price (46)	2		
Linseed meal	Hills (23), Hunziker and Caldwell (26)	2		1
Gluten feed	Goessmann (14), Hunziker and Caldwell (26)	1	1	1
Coconut meal	Albert and Maercker (1), Buschmann (5), Ewing and Spence (12)	1		2
Germ oil meal	Hills (22)			1

In reviewing the earlier work only a few feeds were considered, namely the by-products of some of the oil seeds and corn by-products. Only feeds containing over 15 per cent of digestible crude protein were included, and some oil seeds not in general use in this country were omitted.

The average amounts of digestible nutrients in the feeds are given so that they may be compared conveniently, but only the

analysis for the higher grades of feed are considered and undoubtedly much of the work done with these feeds has been conducted with low grade materials. Where work has been done with cakes this is reported along with the corresponding meals.

It is impossible to discuss each investigation in detail, so for convenience the work of different workers has been tabulated acccording to the nature of the work.

TABLE 5

Changes in fat percentage produced by linseed oil meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Cranfield and Taylor (8), Farrington (18), Hannson (16), Hofmann and Hansen (24), Knieriem and Buschmann (34), Lindsey (35), Ramm, Momsen and Schumacher (50), Speir (52), Thorne, Hickman and Falkenbach (55), Wilson, Curtiss, Kent, Patrick and Eaten (58), Wall (60)	6	5	1
Peanut meal............	Ramm, Momsen and Schumacher (50)			1
Soybean meal	Hansen (17), de Vries (57)	2		
Cottonseed meal........	Hunziker and Caldwell (26)	1		1
Gluten meal...........	Goessmann (15)		1	
Gluten feed.............	Hunziker and Caldwell (26)	1		1
Flaxseed meal...........	Beglarian (3)		1	
Germ oil meal..........	Hills (22)			1

In attempting to digest the previous work on this problem two great difficulties are encountered—some feeds have received more consideration than others, and the conditions under which the various experiments have been conducted are far from uniform. However a few possible deductions are indicated.

With all feeds of high protein content that have been compared with general grain mixtures the chances are about even for an increase in fat percentage or no change; when the same feeds

TABLE 6

Changes in fat percentage produced by gluten meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Cooke (7), Hills (20, 21), Isaachsen and Solvsberg (27), Jordon (28), Ladd (33), Porter (45), Wilson, Kent, Curtiss and Patrick (59)	6	2	
Peanut meal............	Ramm (48)			1
Linseed meal............	Goessmann (15)		1	

TABLE 7

Changes in fat percentage produced by gluten feed

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures.........	Hills (20)	1		
Cottonseed meal................	Goessmann (14)		1	

TABLE 8

Changes in fat percentage produced by flaxseed meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Lindsey (35), Lindsey et al (37)	2		
Linseed meal............	Beglarian (3)		1	

TABLE 9

Changes in fat percentage produced by coconut meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Hannson (16), Juretschke (29), Knieriem and Buschmann (31), Skelton (51), Tancre (54)	4	1	
Peanut meal............	Heinrich (18), Lund (40)	2		
Soybean meal...........	Lund (40)	1		
Cottonseed meal........	Albert and Maercker (1), Buschmann (5), Ewing and Spence (12)	2		1

are compared with each other the chances are about even that an increase or a decrease in fat percentage will result, and on grouping all the trials together the odds are, 2 that an increased fat content will result, 1 that there will be no change, and 1 that there will be a decrease in the percentage of fat in the milk.

TABLE 10

Changes in fat percentage produced by germ oil meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Hills (20, 21, 22)	2	1	
Cottonseed meal ..	Hills (22), Hunziker and Caldwell (26)	2		1
Linseed meal	Hills (22), Hunziker and Caldwell (26)	2		1

TABLE 11

General summary of influences of feeds of high protein content on fat percentage

FEED	GENERAL GRAIN MIXTURES, CHANGES REPORTED			OTHER HIGH PROTEIN FEEDS, CHANGES REPORTED			TOTAL CHANGES REPORTED			TOTAL NUMBER OF TRIALS
	Increase	No change	Decrease	Increase	No change	Decrease	Increase	No. change	Decrease	
Peanut meal..........	3	2	3	1		4	4	2	7	13
Soybean meal.		2	1			5		2	6	8
Cottonseed meal. ..	10	10	2	7	1	5	17	11	7	35
Linseed meal... ...	6	5	1	4	2	4	10	7	5	22
Gluten meal....... . .	6	2			1	1	6	3	1	10
Gluten feed............	1				1		1	1		2
Flaxseed meal.........	2				1		2	1		3
Coconut meal....... ..	4	1		5		1	9	1	1	11
Germ oil meal.........	2	1		4		2	6	1	2	9
Total................	34	23	7	21	6	22	55	29	29	113

If the individual feeds are considered it will be found that in only a few cases can such conclusions be arrived at as the number of trials is generally quite small. In the case of cottonseed meal, which entered into the largest number of trials, conditions are quite similar to those found on grouping all feeds together and the same is apparently true also for linseed oil meal, though in

the few cases where cottonseed and linseed oil meals were compared there was a tendency for the cottonseed meal to give the higher butterfat percentage.

Peanut meal does not appear to directly affect the fat content of milk as the types of change are about evenly distributed though it tended to produce a lower fat percentage when compared with the other feeds of high protein content. Coconut meal appears to increase the fat percentage of milk even when compared with cottonseed meal and other feeds of high protein content. Gluten meal shows increased fat percentage when compared with mixed grain but few comparisons have been made with other feeds containing a large amount of protein. Germ oil meal might also be said to have a tendency to increase the fat content of milk. There is not enough data available on gluten feed and flaxseed meal to allow of any statement being made regarding their value.

EXPERIMENTAL WORK

The work reported here is a record of an attempt to increase the fat content of milk temporarily by replacing certain constituents of the grain ration with cottonseed meal. In one case the cottonseed meal was substituted for oil meal and bran and in another case for corn. An effort was also made to note the result of repeating the cottonseed substitution within a short period of time.

Experiment I

In this trial 6 cows were used and the cottonseed meal was used to replace bran and oil meal in the ration. Data concerning the cows is given in table 1 and where necessary it is calculated to the first day of the experiment, November 14, 1918.

The trial was divided into check, experimental and transition periods. During the transition and check periods the basal ration was fed while the cottonseed meal was substituted during the experimental periods. The transition periods were merely the first portions of the check periods following cottonseed administration and were necessary as a means of indicating the rate of the return of production to normal. The average of the check

periods before and after any experimental period and its accompanying transition period was used as a basis with which to compare the results obtained in the experimental and transition periods.

The experimental animals were fed the roughages, corn silage and alfalfa hay, deemed necessary for their maintenance while the grain rations were uniform in composition but the amounts

TABLE 12

Animals used in experiment I

COW NUMBER	BREED	AGE	WEIGHT	FRESH	BRED
		years	*lbs*	*days*	*days*
223	Jersey..........	5	890	246	96
225	Guernsey..........	5	950	182	14
233	Grade Holstein	$4\frac{1}{2}$	1000	206	85
269	Holstein	4	1160	352	142
282	Grade Holstein	$3\frac{1}{2}$	1110	444	132
311	Grade Holstein..........	3	1120	272	189

TABLE 13

Periods in experiment I

PERIOD NUMBER	NUMBER OF DAYS	WORK
I	4	Check
II	3	Experimental
III	2	Transition
IV	5	Check
V	3	Experimental
VI	3	Transition
VII	4	Check
VIII	3	Experimental
IX	2	Transition
X	4	Check

fed were determined by the production of the individual animals. The basal ration was fed throughout the check and transition periods. During period II the oil meal was replaced by cottonseed meal, while in period V the bran was taken out and cottonseed meal added and in period VIII both oil meal and bran were replaced by cottonseed meal. In each case the cottonseed meal replaced an equal weight of the other feeds and as a consequence

the highest amount of cottonseed meal fed to any cow was 6 pounds per day to cow 233 in period VIII.

The cows were milked twice daily with the exception of cow 233 which was milked three times per day. The animals were handled with the general herd and were allowed out for exercise daily. They were watered twice daily and had salt at free will.

The milk was weighed and tested for butterfat at each milking and the average daily production of milk and butterfat as well as the average percentage of fat was determined for each experimental period.

For convenience the periods are divided into three series, A, B and C, each of the series containing a check, which is the average for the check periods at the beginning and end of the series

TABLE 14

Basal ration used in experiment I

	COW NUMBER					
	223	225	233	269	282	311
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Corn silage	35	35	40	40	40	40
Alfalfa hay	5	5	5	5	5	5
Cracked corn	3	2	4	2	2	2
Ground oats	3	2	4	2	2	2
Wheat bran	3	2	4	2	2	2
Oil meal O. P.	1½	1	2	1	1	1

and an experimental period and transition period which are compared with the check. In each of the cases the average daily production for each animal and for the group is given.

In considering the results it is found that in series A little change in production was found on the average in the experimental period, while in the transition period there was an increase of 5 per cent in the fat content, but as this was accompanied by a 3 per cent decrease in milk yield, there was little change in the total yield of fat. In series B there was a 6 per cent increase in milk yield and a 7 per cent increase in fat yield but little change in the fat content. When series C is reached there is found to be only very small changes in the milk yield and fat content and no change at all in the fat yield.

TABLE 15

Average daily production in experiment I

PERIOD NUMBER	COW 223			COW 225			COW 233			COW 269			COW 282			COW 311			TOTAL		
	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
	lbs.	*per cent*	*lbs.*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*
I	20.8	5.59	1.17	13.4	4.85	0.65	32.4	4.00	1.30	12.4	3.66	0.45	13.5	4.23	0.57	19.8	4.94	0.98	112.2	4.55	5.11
II	21.4	4.93	1.05	14.0	4.68	0.65	34.3	4.16	1.43	13.3	3.38	0.45	14.7	4.00	0.59	18.3	5.36	0.98	115.9	4.55	5.15
III	21.2	5.78	1.23	13.1	5.33	0.70	33.4	3.80	1.27	13.4	3.61	0.48	14.9	4.20	0.62	17.9	5.72	1.02	113.7	4.68	5.32
IV	19.4	5.49	1.07	13.2	4.90	0.65	37.4	3.73	1.39	13.5	3.65	0.49	16.2	4.47	0.73	21.1	4.75	1.00	120.8	4.41	5.33
V	18.8	6.08	1.14	13.6	4.84	0.66	38.4	3.79	1.46	13.4	3.85	0.52	16.9	4.20	0.71	22.2	5.49	1.22	123.3	4.62	5.70
VI	18.6	5.55	1.03	12.4	5.42	0.67	34.6	4.22	1.46	12.3	3.85	0.47	16.0	5.04	0.81	21.5	5.31	1.14	115.2	4.84	5.58
VII	17.4	6.10	1.06	12.3	5.17	0.63	34.0	4.07	1.38	12.0	3.91	0.47	15.3	4.60	0.70	20.1	5.56	1.12	111.0	4.83	5.37
VIII	18.9	5.74	1.09	12.3	4.87	0.60	33.3	4.07	1.35	12.0	3.88	0.47	16.3	4.48	0.73	19.9	5.56	1.11	112.8	4.76	5.34
IX	18.0	6.13	1.10	12.9	4.91	0.63	35.4	3.79	1.34	12.0	3.82	0.46	16.2	4.40	0.71	21.6	5.14	1.11	115.9	4.62	5.35
X	18.4	5.93	1.09	13.6	4.84	0.66	35.6	3.83	1.36	12.3	3.87	0.48	15.4	4.30	0.66	20.5	5.43	1.11	115.8	4.63	5.36

TABLE 16

Comparison of periods in experiment I. Average daily production

SERIES	PERIOD	COW 223			COW 225			COW 233			COW 269			COW 282			COW 311			TOTAL		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs	*per cent*	*lbs.*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs.*
A	Check	20.0	5.53	1.11	13.3	4.87	0.65	35.2	3.84	1.36	13.0	3.66	0.47	15.0	4.37	0.66	20.5	4.83	0.99	117.0	4.47	5.23
	Experimental	21.4	4.93	1.05	14.0	4.68	0.65	34.3	4.16	1.43	13.3	3.38	0.45	14.7	4.00	0.59	18.3	5.36	0.98	115.9	4.55	5.15
	Transition	21.2	5.78	1.23	13.1	5.33	0.70	33.4	3.80	1.27	13.4	3.61	0.48	14.9	4.20	0.62	17.9	5.72	1.02	113.7	4.68	5.32
B	Check	18.5	5.74	1.06	12.8	5.01	0.64	35.9	3.87	1.39	12.8	3.76	0.48	15.8	4.53	0.71	20.6	5.10	1.05	116.4	4.59	5.34
	Experimental	18.8	6.08	1.14	13.6	4.84	0.66	38.4	3.79	1.46	13.4	3.85	0.52	16.9	4.20	0.71	22.2	5.49	1.22	123.3	4.62	5.70
	Transition	18.6	5.55	1.03	12.4	5.42	0.67	34.6	4.22	1.46	12.3	3.85	0.47	16.0	5.04	0.81	21.5	5.31	1.14	115.2	4.84	5.58
C	Check	17.9	6.01	1.07	12.9	5.00	0.65	34.8	3.95	1.37	12.2	3.89	0.47	15.3	4.45	0.68	20.3	5.49	1.11	113.1	4.73	5.36
	Experimental	18.9	5.74	1.09	12.3	4.87	0.60	33.4	4.07	1.35	12.0	3.88	0.47	16.3	4.48	0.73	19.9	5.56	1.11	112.8	4.76	5.34
	Transition	18.0	6.13	1.10	12.9	4.91	0.63	35.4	3.79	1.34	12.0	3.82	0.46	16.2	4.40	0.71	21.6	5.14	1.11	115.9	4.62	5.35

TABLE 17

Percentage increase in production due to cottonseed meal in experiment I

SERIES	PERIOD	COW 223			COW 225			COW 233			COW 269			COW 282			COW 311			TOTAL		
		Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield
A	Experimental	7	−11	−5	5	−4	0	−3	8	5	2	−8	−4	−2	−8	−11	−11	11	−1	−1	2	−2
	Transition	6	5	10	−1	9	8	−5	−1	−7	3	−1	2	0	−4	−6	−13	18	3	−3	5	2
B	Experimental	2	6	8	6	−3	3	7	−2	5	5	2	8	7	−6	0	8	8	16	6	1	7
	Transition	1	−2	−3	−3	8	5	−4	9	5	−4	2	−2	1	11	14	4	4	9	−1	5	4
C	Experimental	6	−4	2	−5	−3	−8	−4	3	−1	−2	0	0	7	1	7	−2	1	0	−1	1	0
	Transition	1	2	3	0	−2	−3	2	−4	−2	−2	−2	−2	6	−1	5	6	−7	0	2	−2	0

Considering the changes as a whole it may be said that the substitution of cottonseed meal for other feeds of high protein content did not influence the production markedly and the effects were not immediate as the changes in the fat percentage were most marked in the transition periods following the times during which the cottonseed meal was fed. It would appear also that the continued administration of cottonseed meal at short intervals results in a decrease rather than an increase in fat content as is demonstrated in series C. Another very noticeable fact is the great variations which occur in the reactions of the individual animals towards the cottonseed meal; no two show the same changes in production.

Experiment II

For this piece of work 4 cows were used and cottonseed meal was substituted for equal weights of cracked corn. Some of the necessary data concerning the animals used is given in table 18 and where necessary it is calculated to August 6, 1919, the day on which the trial commenced.

This trial was divided into periods similar to those in experiment I but as an aid to the interpretation of the results the second period during which the cottonseed meal was fed is divided into two sections of three and four days duration respectively.

The experimental animals were on pasture and were allowed soiling ad libitum and in addition were fed a uniform basal grain ration, the corn portion of which was replaced by cottonseed meal during the experimental periods. Each cow was receiving 3 pounds of cottonseed meal daily during the experimental periods.

The cows were all milked twice daily and had salt and water at free will while on pasture. They were handled with the general milking herd and the milk was weighed and tested and the butterfat yield computed in a manner similar to that used in the first experiment.

The periods in this second experiment are divided into series D and E, similar to the groupings made in the first trial, though the experiment period in series E is considered in two portions.

The cow 319 went off feed with only 3 pounds of cottonseed meal, even when fed in conjunction with an equal weight of oil meal and an equal weight of bran. As a consequence this cow was not carried through the second section of the work and the results obtained with her are considered separately.

TABLE 18

Animals used in experiment II

COW NUMBER	BREED	AGE	WEIGHT	FRESH	BRED
		years	*pounds*	*days*	*days*
161	Holstein	9	1260	446	192
187	Guernsey	9	980	75	39
296	Grade Guernsey	4	900	187	0
319	Holstein	$3\frac{1}{2}$	1290	516	53

TABLE 19

Periods in experiment II

PERIOD NUMBER	NUMBER OF DAYS	WORK
I	6	Check
II	4	Experimental
III	3	Transition
IV	7	Check
V	3	Experimental i
VI	4	Experimental ii
VII	3	Transition
VIII	3	Check

TABLE 20

Basal grain ration used in experiment II

	lbs.
Cracked corn	3
Ground oats	3
Wheat bran	3
Oil meal O. P.	3

If cow 319 is left out of consideration, it is found that in series D an increase of 4 per cent in fat content and 4 per cent in fat yield with no change in the milk yield is obtained in the experimental period, while increases of 2 per cent, 12 per cent and 14 per cent are obtained in the milk yield, fat content

TABLE 21

Average daily production in experiment II

PERIOD NUMBER	COW 161			COW 187			COW 296			COW 319			TOTAL			THREE COWS		
	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
	lbs.	*per cent*	*lbs*	*lbs.*	*per cent*	*lbs.*	*lbs*	*per cent*	*lbs.*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
I	18.0	3.75	0.68	27.5	3.87	1.07	22.1	4 56	1.01	19 3	4.21	0 81	86 8	4 09	3.56	67.6	4.07	2.75
II	19.2	3.90	0.75	26 3	4.25	1.12	23 6	4.63	1.09	17 7	4.12	0 73	86.7	4.25	3 69	69.0	4.29	2.96
III	18.6	4.13	0.77	26.7	4.15	1.11	24 9	5 50	1 37	8.2	6.21	0.51	78.4	4 79	3.76	70.2	4.62	3.24
IV	17.8	3.89	0.69	27.1	4.05	1.10	25.1	4.52	1 13	11.6	5.35	0.62	81 5	4.35	3.54	70 0	4.12	2.92
V	17.3	3.40	0.59	19 3	3.76	0.73	23.9	4.60	1.10							60.5	3.99	2.41
VI	18.0	3.78	0.68	24.9	3.56	0.89	23.8	4.78	1.14							66.8	4.05	2.70
VII	14.8	3.87	0.57	27.9	3.72	1.04	24.4	4.76	1.16							67.1	4.13	2.77
VIII	14.4	3.54	0.51	27.6	3.46	0.95	22.8	4.64	1.06							64.7	3.89	2.52

TABLE 22

Comparison of periods in experiment II. Average daily production

SERIES	PERIOD	COW 161			COW 187			COW 296			COW 319			TOTAL			THREE COWS		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs.	*per cent*	*lbs.*	*lbs*	*per cent*	*lbs*	*lbs.*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs*	*lbs*	*per cent*	*lbs.*
D	Check	17.9	3.83	0.68	27.3	3.97	1.08	23.7	4.54	1.07	15.1	4.67	0.71	84.0	4.23	3.55	68.9	4.13	2.84
	Experimental	19.2	3.90	0.75	26.3	4.25	1.12	23.6	4.63	1.09	17.7	4.12	0.73	86.7	4.25	3.69	69.0	4.29	2.96
	Transition	18.6	4.13	1.38	26.7	4.15	1.11	24.9	5.50	1.37	8.2	6.21	0.51	78.4	4.79	3.76	70.2	4.62	3.24
E	Check	16.8	3.80	0.64	27.3	3.87	1.05	24.4	4.55	1.11							68.4	4.10	2.80
	Experimental (i)	17.3	3.40	0.59	19.3	3.76	0.73	23.9	4.60	1.10							60.5	3.99	2.41
	Experimental (ii)	18.0	3.78	0.68	24.9	3.56	0.89	23.8	4.78	1.14							66.8	4.05	2.70
	Experimental	17.7	3.62	0.64	22.5	3.63	0.82	23.9	4.70	1.12							64.1	4.03	2.58
	Transition	14.8	3.87	0.57	27.9	3.72	1.04	24.4	4.76	1.16							67.1	4.13	2.77

TABLE 23

Percentage increase in production due to cottonseed meal in experiment II

SERIES	PERIOD	COW 161			COW 187			COW 296			COW 319			TOTAL			THREE COWS		
		Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield
D	Experimental	7	2	10	−4	7	4	−1	2	2	17	−12	3	3	0	4	0	4	4
	Transition	4	8	13	−2	5	3	5	21	28	−46	33	−28	−7	13	6	2	12	14
E	Experimental (i)	3	−11	−8	−29	−3	−31	−2	1	−1							−12	−3	−14
	Experimental (ii)	7	−1	6	−9	−8	−15	−2	5	3							−2	−1	−4
	Experimental	4	−5	0	−18	−6	−22	−2	3	1							−6	−2	−8
	Transition	−12	2	−11	2	−4	−1	0	5	5							−2	1	−1

and fat yield respectively. This indicates that the cottonseed meal did increase the fat content and fat yield without having much influence on the milk yield and that the full effect was not noticeable until after the administration of the cottonseed stopped. In series E there were decreases in milk yield, fat content and fat yield during the experimental period and they were most noticeable during the early part of the administration, thus showing that the second administration of cottonseed shortly after the first depressed rather than increased production of both milk and butterfat. By the time the transition period was reached and the cottonseed meal taken out of the ration, production tended to come back to normal.

In the case of cow 319 the administration of cottonseed meal for the first time depressed the fat content markedly and increased the milk yield so that there was little change in the total fat yield. The small amount of cottonseed meal used caused her to go off feed and by the time the transition period was reached the milk and fat yields had decreased enormously and the fat content showed a 33 per cent increase.

Reviewing the results of the second trial broadly it may be said that the replacing of corn with cottonseed meal tended to increase the fat content of the milk and the total yield of fat though a repetition of the work within a short time had an inhibitory effect on production. Greater uniformity was shown in the response of the cows to the cottonseed than was found in the first experiment, with the exception of one cow that was thrown off feed by a limited amount of cottonseed meal.

DISCUSSION OF RESULTS

In considering the work that has already been reported on the influence of feeds of high protein content on the fat content of milk it is found that there is no uniformity in the results obtained, and this holds true even when a feed such as cottonseed meal is considered. This lack of similarity in the results obtained is due probably to a considerable number of factors, the most important of which is undoubtedly a lack of uniformity in the

conditions under which the investigations were conducted. The basal rations differed in practically all cases and many other conditions were also allowed to vary.

When the investigations reported here are considered it is found that on substituting cottonseed meal for other feeds containing a liberal amount of protein only slight increases in the fat percentage were obtained but when cracked corn was replaced by cottonseed meal a more marked increase in fat percentage resulted. These are the two main facts but in addition it should be remembered that the increase in fat content did not take place immediately after the substitution of the cottonseed meal, that a readministration of cottonseed within a few days of the first tended to decrease rather than increase the fat content, and that cows vary in their reaction towards cottonseed, some going off feed when even limited amounts are fed.

The present day status of our knowledge does not allow of any definite reasons being given for the changes noted in the present experiments on the feeding of cottonseed meal but a few possible reasons can be discussed.

The palatability of a feed may influence not only the amount of feed consumed but also the degree to which it is utilized and so improved palatability as the result of a change in ration might lead to improved production. This cannot hold true in the cases considered however as cottonseed meal is relatively unpalatable when compared with the feeds for which it was substituted and in addition the rations were controlled in amount.

It is a recognized fact that certain feeds will bring about digestive disturbances and that sudden or radical changes in the ration will produce like effects. Cottonseed meal is one of the feeds, which, on account of its constipating action, may produce digestive troubles if introduced suddenly into the ration or if fed in considerable proportions for too long a period. This effect of the cottonseed might be supposed to have brought about the increase in fat content as digestive disturbances generally result in a decreased milk yield and increased fat percentage. However the greatest changes in fat percentage occurred where the cottonseed meal was substituted for corn and feeds that counter-

act the constipating action of the cottonseed meal, namely, oil meal and bran, were allowed to remain in the ration; and the smallest most irregular changes were produced where cottonseed meal was substituted for the laxative feeds, oil meal and bran. Consequently, therefore the changes produced cannot be attributed to digestive derangements produced by the cottonseed meal. Neither can the sudden introduction of the cottonseed meal into the ration be looked on as the cause as it was introduced suddenly into both rations. In the case of one cow only in the second experiment can the changes produced be attributed to digestive derangements produced by cottonseed meal—it was unpalatable to her, caused digestive troubles, and the limited amount fed to her put her off feed, decreased her milk production markedly and increased the fat content of the milk.

The addition of protein to a ration has been shown to increase the digestibility of protein and carbohydrate material present though this is of course most evident in the case of rations originally low in protein. The additional nutrients thus digested might be used for the production of milk and butterfat, though of course excess nutrients would be used for the production of body fat or energy. The excess of protein, over that required for maintenance and production, would be katabolised and the nitrogen excreted in the urine, though the non-nitrogeneous portions of it would be used for the production of energy. This function of the protein may explain in part the results of the two trials reported. The substitution of cottonseed meal for corn in the second trial increased the protein content of the ration markedly and so may have resulted in the increased fat content of the milk, while the replacement of other feeds by cottonseed in the other trial did not produce such a marked increase in protein content of the ration and was accompanied by no marked change in the percentage of fat in the milk.

The effect of protein in increasing the heat production of the animal body is known as its specific dynamic action and the increased katabolism brought about in this way might result directly or indirectly in an added impetus to milk production. Consequently, the increased fat percentage in the milk in the

second series might be due to this function of the additional protein provided by the cottonseed meal while the fact that the milk fat was not increased markedly in the first series may be due to the fact that the protein supply of the ration was not so markedly increased as it was in the later trial.

The protein of a feed may also have a direct stimulating action on the metabolic activities of the protoplasm of the epithelial cells in the alveoli in the mammary gland, and, if this be so, the stimulation due to the excess amount of protein supplied in the second trial might account for the increased fat percentage found in the milk at that time.

In addition to the direct influence of the protein of the cottonseed meal, other possible properties of the cottonseed meal have to be considered. It is frequently stated that the amount of fat or oil in a ration will influence the percentage of fat in milk. On the whole however, there is no definite evidence that it will do so, and the fat content of cottonseed meal differs so little from that of the feeds for which it was substituted that this factor need be given but little consideration.

It is also recognized that some feeds possess an ability to stimulate milk production quite independent of the nutrients which they contain though but little is known of these properties at present and as cottonseed was added in both trials and very dissimilar results ensued, the changes produced can hardly be attributed to any specific, but undetermined, stimulant in the cottonseed meal.

There remains another condition to consider—when cottonseed meal was administered for the second time in each experiment, there was a greater or less tendency for the fat content to decrease rather than increase. This would point to the cottonseed acting as a stimulant rather than its direct utilization for production, and to the fact that the cow, once she has reacted to its stimulating action, has to be rested for some time before she can again respond in a similar manner. Corresponding results with the use of stimulants for various purposes are quite common and need no discussion or illustration.

SUMMARY

From the work reported here the following deductions are probably justified:

1. The substitution of cottonseed meal for old-process linseed oil meal and bran in the ration of milk cows produces no marked change in the percentage of fat in milk.
2. The replacing of cracked corn with cottonseed meal under similar conditions, and in even limited amounts, tends to cause an increase in the fat content of milk.
3. All cows are not uniform in their reaction towards cottonseed meal.
4. In some cases a limited amount of cottonseed meal introduced suddenly into the ration will cause cows to lose appetite, to be subject to digestive disturbances and to decrease markedly in milk production. The large decrease in milk production will be accompanied by a high butterfat content.
5. Increases in butterfat content due to sudden administration of cottonseed meal take place in a comparatively short time and are not of long duration.
6. The readministration of cottonseed meal, before the cows have had time to recover from the effects produced during the first administration, tends to decrease rather than increase the fat content of the milk.
7. The effects produced by the cottonseed meal are probably due to some stimulating effect of the protein, either on general metabolism or on the activity of the mammary gland, which is not as yet completely understood.

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THE EFFECT OF COTTONSEED MEAL UPON THE GROWTH AND REPRODUCTION OF COWS

STANLEY COMBS AND R. S. CURTIS

North Carolina Agricultural Experiment Station, West Raleigh, North Carolina

Each year the problem concerning the effect of cottonseed meal upon the growth and reproduction of breeding animals becomes more acute. Cottonseed meal is one of the South's greatest feed crops and it supplies the cheapest source of protein for a large area in which the live stock industry is rapidly increasing. In the production of milk it constitutes an important part of the ration. In the feeding of beef cattle it plays an important part in the ration, and in many instances, it constitutes the sole grain ration. In the feeding and development of both classes of animals it could be used more effectively were its effects upon the growth and reproduction of such animals definitely known.

In order to secure more definite information in regard to the effect of this feed upon beef and dairy cows, the Dairy Experimental Office at Raleigh, in coöperation with the Office of Beef Cattle and Sheep, began a study in 1915. At this time the work was started on a small scale, which was preliminary work for that which is under way at the present time. In order to convey an idea of the scope of this work, it might be well to state that twenty animals were secured November 1, 1915. These animals ranged in age from six months to slightly more than a year. The average age for the entire lot being considerably under one year. The average weight of these animals at the beginning of the work was 356 pounds. These animals were divided into four lots and fed as shown in tabulation on page 335.

Before tabulating any of the results attained in this work, it may be well to again call attention to the age of these animals. The effect of a ration is more noticeable with young animals than those that are more mature. Had these rations been fed to mature cows, the results may have been far different. Therefore,

LOT NUMBER	NUMBER OF ANIMAL	RATION FED
I	327 328 329 330 331	Cotton seed meal (1 pound daily per 100 pounds live weight) Cottonseed hulls ad libitum
II	347 348 349 350 351	Cottonseed meal one-half, crushed corn one-half (1 pound daily per 100 pounds live weight) Cottonseed hulls ad libitum
III	352 353 354 355 356	Cottonseed meal (1 pound daily per 100 pounds live weight) Cottonseed hulls one-half, corn silage one-half; ad libitum
IV	357 358 359 360 361	Cottonseed meal (1 pound daily per 100 pounds live weight) Copper sulphate solution* Cottonseed hulls ad libitum
V†	362 363 364 365 366	Cottonseed meal (1 pound daily per 100 pounds live weight) Cotton seed hulls one-third; beet pulp two-thirds; ad libitum

* This solution was prepared by dissolving 1 pound of copper sulphate in 50 gallons of water and sprinkling the feed with 1 quart of this solution for each pound of cottonseed meal in the ration.

† This lot was added on December 13, 1915. The animals were older and larger than the preceding lots. The average weight of this lot being 615 pounds, Nos. 365 and 366 were several months younger than the other three.

it is unfair to assume that the results obtained in this test will, apply to all ages and classes of cows.

As the work progressed, some of the results may be noted as follows:

No. 327. Died January 21, 1916 (82 days after starting on this feed).

No. 330. Three fits followed by death on January 23, 1916 (84 days after starting on this feed).

No. 351. Fit of February 8 and another on February 26. Died March 13, 1916 (133 days after starting on this feed).

No. 349. Fit on April 30 and May 1. Died May 27, 1916. Totally blind (208 days after starting on this feed).

No. 359. Fit May 1, 1916.

No. 360. Died June 5, 1916 (217 days after starting on this feed).

No. 365. Discontinued from ration early in June. Died June 9, 1916 (221 days after starting on this feed).

No. 366. Discontinued from ration early in June. Died June 9, 1916. Totally blind (221 days after starting on this feed).

No. 328. Discontinued from ration. Died a few days later on June 10, 1916 (222 days after starting on this feed).

No. 331. Discontinued from ration. Died a few days later on June 14, 1916 (226 days after starting on this feed).

No. 329. Discontinued from ration. Died a few days later on June 14, 1916 (226 days after starting on this feed).

From the above it may be noticed that all of the animals in lot I died. The animals remaining in lots II and III were discontinued from their rations on June 11, 1916. These animals were sluggish and very much weakened.

No. 328. Aborted February 24, 1916.

No. 329. Calved April 14, 1916. Calf deformed, blind and was killed.

No. 331. Calved June 3, 1916. Calf weak. Weight 34 pounds. Died.

No. 364. Calved October 16, 1916. Calf seemed normal but died.

RESULTS AT CALVING TIME

Lots IV and V were discontinued January 1, 1917. All animals weak and partially blind, however, the three largest and oldest cows out of lot V were kept and put on a ration of cottonseed meal and hulls. The ration for these three animals (including the present time) is 1 pound of cottonseed meal daily for each 100 pound of live weight, with all the cottonseed hulls they will consume.

The numbers of these animals were changed from 362, 363 and 364 to 101, 102 and 103 respectively. At present no. 101 consumes 14.2 pounds of cottonseed meal and 24 pounds of hulls daily No. 102 receives 11.3 pounds meal with 30 pounds of hulls; and 103 gets 12.9 pounds meal and 30 pounds of hulls daily. During the summer months this meal will be reduced 50 per cent or from April 15 to October 15. The accompanying photographs will convey some idea of the condition of these animals at the present time.

OUTLINE OF THE PRESENT WORK

During March, 1919, twenty high grade calves were secured, ranging in age from two to ten weeks. These calves had been started on Blatchford's calf meal, therefore this ration was continued for six months. The aim during the first year was to keep this young herd in a good thrifty growing condition. Beginning with January, 1920, these animals were divided into five lots of four calves each. Their ration is as follows:

LOT	RATION
I	Cottonseed meal one-half, crushed oats one-half* (1 pound daily per 100 pounds live weight) Cottonseed hulls ad libitum
II	Cracked corn (1 pound daily per 100 pounds live weight) Corn silage two-thirds, corn stover one-third; ad libitum
III	Cottonseed meal one-half, cracked corn one-half (1 pound daily per 100 pounds live weight) Cottonseed hulls one-fourth, corn silage two-fourths, corn, stover one-fourth; ad libitum
IV	Cottonseed meal (1 pound daily per 100 pounds live weight) Corn silage ad libitum
V	Cracked corn three-fifths, wheat bran one-fifth, linseed meal one-fifth (1 pound daily per 100 pounds live weight) Alfalfa hay one-third, corn silage two-thirds; ad libitum

* The crushed oats will be replaced with cottonseed meal, beginning November, 1921.

These animals have been weighed each two weeks during the past year and feed adjustments made at each weighing period. The condition of the animals and the amount of growth has been fairly satisfactory up to the present, February, 1921. The growth may be noted from the following table:

LOT	AVERAGE WEIGHT BY LOTS		AVERAGE LOT GAIN
	January, 1920	February, 1921	
	pounds	*pounds*	*pounds*
I	399	824	425
II	390	722	332
III	397	826	429
IV	396	721	325
V	375	821	446

The breeding work was started about the middle of November, 1919, and at present the majority of these animals seem to be safe with calf.

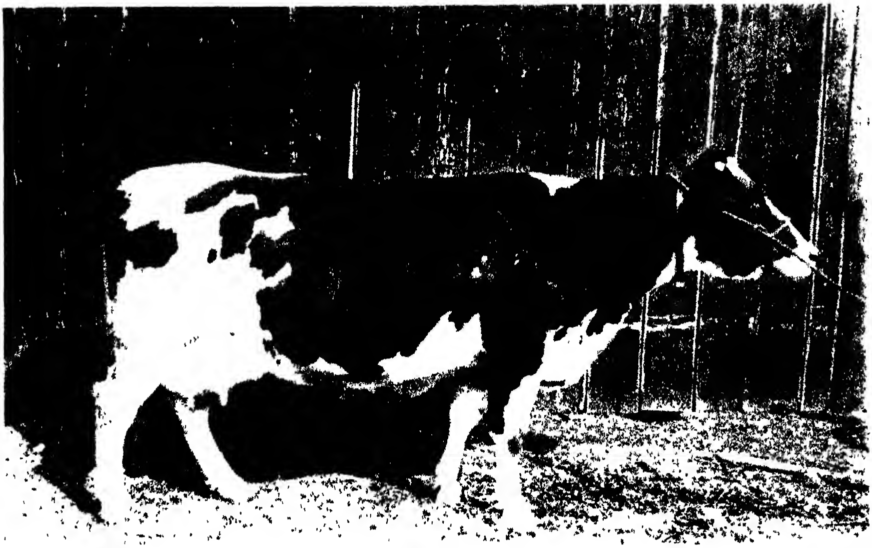

FIG. 1 COW NO 101, FEBRUARY 7, 1921

Calved February 8, 1921. Twin calves, weighed 72 and 88 pounds each; normal. Cow had been eating 14 2 pounds of cotton-seed meal daily and will be continued on this amount for four months with all the hulls she will consume.

FIG. 2 TWIN CALVES OUT OF COW NO. 101, FEBRUARY 10, 1921

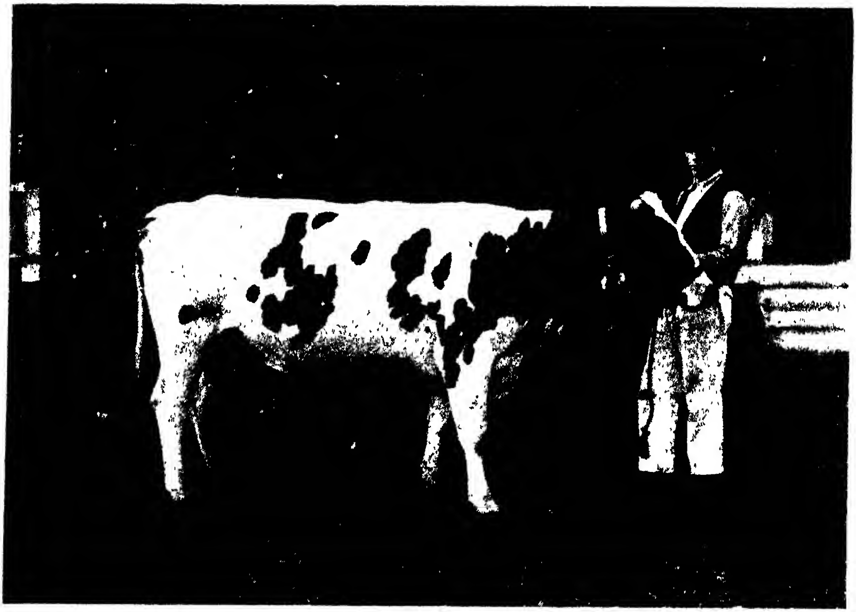

FIG. 3. COW NO. 102, JANUARY, 1920

Consuming 12.3 pounds of cotton-seed meal daily. She gave birth to twins on June 11, 1919; normal; weighed 55 and 61 pounds each. On October 6, 1920, she calved again, calf being normal and weighed 62 pounds. She is now consuming 11.3 pounds of cotton-seed meal daily, the rest of her ration being hulls.

FIG. 5. COW NO. 103, NOVEMBER 30, 1920

Calved December 1, 1920. Was consuming 12.9 pounds of cotton-seed meal daily.

FIG. 6. CALF OUT OF NO. 103, JANUARY 20, 1921

AVAILABILITY AND USEFULNESS OF DAIRY STATISTICS[1]

Dairy statistics, taken in their entirety, cover a broad field. Intelligent action throughout the entire field of marketing of the industry is based largely upon current or statistical information, and the more complete and reliable the information, the more useful and valuable it becomes as a basis for safe conclusions. Undertake, for example, to study the trend of any branch of the dairy industry without reliable statistical information and you will immediately realize how futile is your attempt. Attempt to study the progress made in the pure bred cattle industry, the growth of the cow-testing or bull association movement without statistical information or attempt to determine the trend of the butter, cheese, condensed milk, or milk powder industries, without data on the monthly or annual production and it becomes obvious immediately that it is next to impossible to reach any very definite conclusions.

It would be practically useless to attempt to estimate the per capita consumption of butter or dairy products in the absence of data on production, or to attempt to make a study of the world's trade in dairy products without data regarding the exports and imports of the leading dairy countries.

In the field of advertising and merchandising, statistics are of incalculable value. If the problem be that of advertising and selling cream separators in a certain State or section, data on such factors as the following would be most useful: Number of farms, number of dairy cows, number of creameries, number of cream buying and shipping stations, amount of butter made on farms and in factories, prices of butter fat and butter compared with

[1] Report of the Committee on Statistics on Production and Marketing of Dairy Products, presented at fifth annual meeting of the American Dairy Science Association held at Chicago, Illinois, October 11, 1920. Roy C. Potts, Chairman of Committee; O. F. Hunziker, E. S. Guthrie, C. E. Lee and S. C. Thompson, members.

other sections, and the profitableness of dairying compared with other sections and with other lines of agriculture.

If the problem be that of analyzing the present condensed milk situation, the actual conditions which now exist. the causes which have produced these conditions, and the effect of possible as well as probable factors in improving these conditions, it is statistical information that must be relied upon and used in analyzing the whole situation. Such statistics should include the monthly productions of all factories for each class of product, the stocks in the hands of manufacturers, the stocks in the hands of jobbers and wholesale grocers, the exports and imports and general market conditions, especially those affecting the demand. At the present time, the condensed milk market situation is not most satisfactory to producers or manufacturers. Later in this report, certain data available with reference to this industry will be presented and analyzed.

STATISTICS OF THE DAIRY INDUSTRY WHICH ARE VALUABLE TO THE INDUSTRY

Enough has been said in the foregoing statements to indicate clearly the value of statistics to the dairy industry. Three facts which are especially worthy of note by this Association may be ment oned:

1. A great deal of dairy statistics are at present available, but those to whom these statistics are of most value often do not know that the desired statistics exist or do not know how they may be obtained.

2. A great deal of dairy statistics which are not at present available could be made available if those in position to produce the statistics appreciated the usefulness and value of such statistics to the dairy industry.

3. Agencies of the federal government should have authority and the necessary finances to assemble from all sources the essential and useful dairy statistics and through coöperation with other agencies assist in the development of such useful statistics as are not now available.

The various dairy statistics of value to the industry may be classified as follows:

- Farm resources:
  - Acreage adapted to various crops
  - Acreage of and production of various crops
  - Comparative costs of production
- Farm equipment:
  - Dairy barns
  - Silos
  - Cream separators
- Dairy cattle (purebred vs. others):
  - Number cows in milk
  - Number heifers
  - Number bulls
- Production associations:
  - Cow testing
  - Bull associations
- Milk production:
  - Production per cow
  - Total amount produced
- Dairy factories:
  - Number, location, kind and amount of products produced.
- Uses made of milk and its products:
  - Consumed on farms
  - Manufactured on farms
  - Consumed in cities
  - Manufactured in factories
- Stocks of dairy products and substitutes:
  - Manufactured and warehouses by manufacturers
  - Received at markets
  - In hands of dealers
  - Held in cold storage
  - Shipped to foreign countries
  - Received from foreign countries
- Costs and prices:
  - Costs of dairy farming land
  - Costs of dairy cattle
  - Costs of dairy feeds
  - Costs of dairy labor

Costs of production of milk per cwt.
Costs of manufacturing dairy products
Costs of distribution of dairy products
Farm and market prices of dairy products

Referring to this classification, it will be noted that it includes two main sets of conditions: (1) Those on farms, and (2) those off of farms.

Except for the items of "Acreage adapted to various crops," which is chiefly a soil survey problem, and that of "Comparative costs of production," which is a farm management problem, the farm statistics are those which properly might be included in the agricultural census and continued annually in estimates by the Bureau of Crop Estimates[2] of the United States Department of Agriculture in coöperation with the State Department of Agriculture or State Statistical Agents of the Department.

The statistics off of farms except for those of exports and imports which are compiled by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, are principally marketing statistics and the Bureau of Markets[2] of the United States Department of Agriculture is undertaking to develop these statistics with the limited funds and facilities available for such work.

ILLUSTRATIONS OF THE USES WHICH MAY BE MADE OF DAIRY STATISTICS

Illustration 1. On January 1, 1920, the Bureau of Crop Estimates reported the number of milch cows in the United States as 23,747,000 as compared with 23 455,000 January 1, 1919. What significance has this report to the dairy industry?

Potential possibilities of increased production are indicated by an increased number of dairy cows, but a study of certain other statistics must be made before we can say how this increase will affect the dairy industry. We must know in what sections the increases have occurred, also the decreases. We must

[2] On July 1, 1921, the Bureau of Crop Estimates and the Bureau of Markets were combined into one Bureau—that of "Markets and Crop Estimates."

know the conditions which caused the increase and into what market channel the increased product will be put. We should also know the trend of the uses made of milk in other sections. With such additional information, the number of dairy cows on January 1, 1920, compared with 1919, may have some definite significance to the butter and cheese manufacturer, or to the cream separator, dairy barn equipment, or silo manufacturer. This illustration is quite typical of most statistical facts. Unless other supplementary statistics are obtainable, many of the primary statistics available can not be interpreted, and without interpretation they are of limited usefulness.

Illustration 2. The total stocks of condensed and evaporated whole milk (case goods) in the hands of manufacturers on September 1, 1920 and August 1, 1920, were as follows:

	SEPTEMBER 1, 1920	AUGUST 1, 1920
Condensed case	69,691,287	65,366,996
Evaporated case	164,571,905	142,647,134

What significance have these figures to producers, manufacturers, and dealers?

We note that September 1 stocks are larger than August 1, but this alone tells us very little. We need certain other information in order to draw any very definite conclusions. First, we want to know whether the stocks on September 1, 1919, represent a normal or surplus stock. We also want to know how much of the stock reported on hand is unsold stock. We also want to know the amount of unfilled orders. Furthermore, it would be interesting to know the amount of unsold stock carried at New York City. The desirability of having this additional information will be obvious by reference to the monthly report on the "Condensed and Evaporated Milk Market," issued by the Bureau of Markets.

The following report of conditions of the market was issued by the Bureau on September 28, 1920, and is based largely on the statistical information received from manufacturers.

UNITED STATES DEPARTMENT OF AGRICULTURE BUREAU OF MARKETS,
WASHINGTON, D. C.

September 28, 1920.

CONDENSED AND EVAPORATED MILK MARKET REPORT FOR SEPTEMBER, 1920

Condensed Milk Manufacturers Close Factories in Effort to Curtail Production. Prices Decline with Decrease in Exports and Increase in Stocks.

During the past two months the condensed and evaporated milk market has steadily been getting into worse shape, and now has reached a critical stage with many manufacturers.

Export business, which stimulated increased production during the war and the building of many new factories, is now at a standstill. Companies which have been exporting have put their stocks on the domestic market, flooding it with goods which are offered at cut-rate prices in order to get their money out of it. Among the factors contributing to a decreased foreign demand is the increased production of foreign countries, which is being offered by Holland, Norway and Denmark in this and other countries at prices below our own.

It is reported that jobbers and wholesale grocers, in expectation of still lower prices, are not taking on any large stocks and are buying mostly for immediate sale to retail trade. The "tight money" condition is said to be a factor with many manufacturers and jobbers, causing them to unload at least a portion of their stocks previously made of higher priced sugar at prices below actual cost.

Report of the stocks in hands of manufacturers on September 1 shows that the load carried had increased, while unfilled orders had become practically "nil" on bulk goods and on case goods they were below those of August 1. Some firms reported their stocks were larger than ever in their history and the bottom had practically dropped out of the market. During September, it has been a serious question in the minds of many manufacturers as to what to do on October 1, with producers in most sections contending for higher prices for milk. Some few manufacturers have offered to coöperate with producers in further manufacturing and holding of stocks until sold, before determining prices to be paid the milk producers. Others announce they will close their factories until the present situation improves. Such action

will result in curtailed supply, permitting present stocks to be worked off at prices more satisfactory to holders.

Of the twenty-and-a-half million pounds of condensed milk exported in August, over ten million went to the United Kingdom, nearly three million to Cuba, and nearly 1½ million to the Straits Settlements. Of the five million pounds of evaporated, France took nearly two million, the United Kingdom 1,220,000 and Cuba nearly 375,000, and other countries less than 200,000 pounds each.

Current prices on evaporated case goods range from $5.00 to $7.00 per case, and on condensed, from $5.00 to $10.50, with advertised brands bringing the higher prices.

Skim condensed bulk is quoted at $8.75 to $9.50 per cwt., and condensed whole milk in bulk at $15 to $16 per cwt.

Illustration 3. It is reported that a firm in San Francisco has contracted for 1000 long tons of New Zealand butter to be delivered at a laid down price (duty paid) of less than 50 cents. We would like to know what the probabilities are of even larger quantities being exported to this country from New Zealand and the probable effect of such shipments on our markets.

Since shipments of New Zealand Butter to the United States are unusual, we may inquire where New Zealand formerly marketed her surplus, how much she marketed, her past production compared with her present, and the conditions in the country which formerly purchased the surplus of New Zealand which are operating to increase or decrease the present or future demand for New Zealand butter. Then, too, we may consider the conditions which are favorable, also unfavorable, to present and future sales in the United States.

Storage stocks on the English market are very light and both Denmark and Argentina are shipping considerable amounts to the United States and figure on continuing with even larger shipments. Some time ago the English Food Ministry contracted for 9000 tons of Danish butter at 245 shillings per cwt., c. i. f., for storage, and the entire surplus of Australia at 275 shillings per cwt., f. o. b. port in Australia. Even with these supplies, it is reported there will be quite a shortage in the English market. Canadian stocks in storage show a shortage on August 1, 1920, of over 16 per cent.

All conditions point to an urgent demand in England for New Zealand's surplus and the Food Ministry undoubtedly will offer many inducements in order to obtain it. Until contracts are made with the Food Ministry, there are very good possibilities of New Zealand butter reaching our markets throughout the coming winter season. The balance of trade and exchange situation, also other factors, seem to favor it. The cost of delivering New Zealand butter in the United States is about $4\frac{1}{4}$ cents per pound, duty paid. Butter now in storage in San Francisco will cost upwards of 50 cents during next December and January with storage carrying charges included. On this basis New Zealand butter would net the New Zealand exporter 46 cents or better, f. o. b., New Zealand, which is more than the English contract price for the Australian surplus. Unless the Food Ministry can square accounts on the contracts for Australian butter, and meet a price of 46 cents for New Zealand butter, the New Zealand butter is sure to come to our markets. (Since the foregoing was written, a report has been issued that the Food Ministry has contracted for the surplus from New Zealand at 46.6 cents, f. o. b., New Zealand.)

Other examples might be cited, but perhaps those given will suffice to indicate fully the value and usefulness of dairy statistics. This phase of dairy work is worthy of much larger development, and this Association should promote in every way possible the attainment of that end.

Roy C. Potts,
Chairman of Committee.

THE SAMPLING OF MILK

H. F. JUDKINS

Massachusetts Agricultural College, Amherst, Massachusetts

The bulk of the market milk handled in our cities is bought by the quart, gallon, can or hundred weight, a certain base price being paid for milk containing a certain per cent of fat plus or minus a butter fat premium. The question of how to accurately determine the average per cent of fat in the milk of their patrons month by month and keep everybody satisfied is a problem milk dealers have been facing for some time.

Obivously the most accurate method would be to sample and test each patron's milk daily. This, however, would necessitate so much work as to make it impractical.

Some methods in use involve the taking of composite samples and testing them usually, every two weeks. Sometimes aliquot portions of each day's milk are taken using the sampling tube, and sometimes the same amount is taken out of each delivery by using a small dipper.

Some plants sample and test from one to five times a month and calculate the average test by adding up the tests and dividing by the number of tests made or by figuring out the true average test by determining the total pounds of fat bought during various test periods of the month and dividing this by the monthly weight of milk.

Hunziker (1) reports the following as average results on 4200 daily samples and 700 composite samples covering a period of fourteen days.

Method of sampling	*Per cent fat*
Daily samples	4.900
Composite samples, aliquot portions	4.865
Composite samples, equal portions	4.870
Daily samples, every second day	4.914
Daily samples, every third day	4.905
Daily samples, every fourth day	4.903
Daily samples, every fifth day	4.893

It is understood in the last four cases that the sum of the tests involved was divided by the number of tests to get the average test for the period. This point is not perfectly clear, however.

Kent (2) compared the daily and composite tests for a period of thirteen days. There were fifty-two patrons. Three samples were taken as follows from the milk delivered by each patron. A daily test sample, a composite sample obtained by use of a small dipper, and a composite sample for which a Scoville sampling tube was used. The average test was 4.01 per cent, the dipper composite test was 3.95 per cent and the Scoville tube composite was 4 per cent.

Potts (3) carried on the following experiment taking composite and daily samples in the following manner: Composite A was taken with a little dipper which was attached to a stirring rod, B was taken with a metal tube which very nearly secured an aliquot portion, and C was taken rather carelessly with a McKay sampler. This milk was delivered by 60 patrons. There were 420 daily tests and 60 composite tests made. This experiment continued seven days with the following results: Daily test 4.39 per cent; composite A, 4.352 per cent; composite B, 4.363 per cent; composite C, 4.384 per cent.

He ran another set of tests for a period of fourteen days. The samples were all taken in the same manner, giving practically the same results. Daily test, 4.131 per cent; composite A, 4.039 per cent; composite B, 4.00 per cent, and composite C, 4.044 per cent.

All the above results indicate that any of the various methods used were accurate enough for practical purposes.

With the idea of checking up this work over a longer period of time and showing variations, the writer carried on an experiment during January and February, 1920. The milk of the 12 patrons delivering milk to the Massachusetts Agricultural College Dairy Department was sampled and tested daily. Composite samples were also taken with the milk thief and a small dipper, and tested twice a month. The Department buys its milk at a base price per quart for 3.5 per cent milk plus or minus one-tenth of a cent a quart for each tenth of a per cent of fat

above or below 3.5. per cent. Milk is paid for once a month, hence the need of getting at the monthly test of each patron's milk. In addition to the above plans, tests taken on the 15th and 30th of the month were divided by two to get the monthly average and the true average test with these two tests as the basis was also figured. This was likewise done for three tests taken on the 10th, 20th and 30th of month. These two schemes are in more or less common use in New England milk plants.

The first table shows the average tests by the various methods for the two months.

TABLE 1

Showing average percent of fat; in 12 patrons' milk for a period of two months

MONTH	POUNDS OF FAT, DAILY TEST	PER CENT OF FAT, DAILY TEST	POUNDS OF FAT, TUBE TEST	PER CENT OF FAT, TUBE TEST	POUNDS OF FAT, DIPPER TEST	PER CENT OF FAT, DIPPER TEST
January.....	1372.063	4.047	1375 912	4 058	1380.865	4.073
February...	1498.475	3 956	1516.873	4.007	1530.907	4.044
Average..		3 999		4 030		4.056

MONTH	POUNDS OF FAT, 2 TESTS	AVERAGE TEST, 2 TESTS	AVERAGE TEST, SUM OF 2 TESTS DIVIDED BY 2	POUNDS OF FAT, 3 TESTS	AVERAGE TEST, 3 TESTS	AVERAGE TEST, SUM OF 3 TESTS DIVIDED BY 3
January..	1343.672	3.963	4 120	1361.926	4.011	4 025
February...	1456 363	3.845	4.150	1493.180	3.942	4.158
Average		3.901	4 135		3.977	4.091

Table 1 shows a remarkably close agreement in the average test when worked out by the seven different methods. When the test is calculated by adding up two tests taken at the middle and end of the month, and dividing them by two, there seems to be the greatest difference from the average test found by daily testing. The others are in so close agreement as to be within the limit of error.

While averages may check out closely as in table 1, it becomes of interest to know how wide the variations are from the average of daily tests.

Figures in table 2 are based on the deliveries of twelve patrons covering a period of two months. The first column of figures

shows the number of times the various methods of figuring the average test for the two months differed 0.2 per cent or more from the average obtained by daily testing. The possible numbers in this column would be 24. One can see at a glance that any of the methods seem sufficiently accurate with the exception of using two tests as a basis and either calculating the true average or dividing the sum of two tests by two. Here the error is sufficiently large enough times to introduce unfairness with a number of patrons.

TABLE 2

Showing variations; in different methods of arriving at monthly average tests

METHOD	NUMBER OF TIMES DIFFERENCE IS 0.2 PER CENT OR MORE	SMALLEST DIFFERENCE	LARGEST DIFFERENCE	AVERAGE DIFFERENCE
Tube + or − daily test	1	+0.012	+0.209	+0.031
Dipper + or − daily test	1	−0.007	+0.250	+0.057
Dipper + or − tube test	0	0.000	+0.186	+0.026
Sum of 2 tests ÷ 2 + or − daily test	6	+0.009	+0.415	+0.136
True average test 2 tests + or − daily test	5	+0.007	+0.404	−0.098
True average test 3 tests + or − daily test	1	−0.015	+0.204	−0.022
Sum of 3 tests ÷ 3 + or − daily test	1	−0.003	−0.204	+0.092

The dipper and tube methods seem to be practically equally accurate methods of sampling when samples are tested every two weeks and daily deliveries of milk do not vary much in weight.

Since considerable figuring is necessary to calculate the true average test of a large number of patrons when samples are taken three times a month it is very interesting to note that the last method mentioned in the table, namely, adding up the three tests and dividing by three comes so near the results obtained by daily testing and even nearer those obtained by composite sampling. The method is worthy of recommendation. It is the method now used by the Massachusetts Agricultural College Dairy Department. Of course a possible objection to the method is, that if the sampling is done on regular days the patrons may

try to slip in some adulterated milk occasionally. However, varying the testing days so they fall at different times in the month, but at approximately ten day intervals overcomes this objection. The more times tests are taken during the month the more accurate results should be. Three times seems to be sufficient, however. About the only other alternative is to run composite samples and test them every two weeks. This involves, all told, more labor than sampling three times a month and in the summer time one is confronted with the problem of keeping composite samples in good enough condition so results will be accurate.

REFERENCES

(1) HUNZIKER, O. F.: Twenty-seventh Annual Report of the Purdue Experiment Station.

(2) KENT, F.: Testing milk and cream. Oregon Experiment Station Bul. No. 70.

(3) POTTS, A. E.: Sampling of milk. Thesis in Cornell University Library.

OPEN FORUM

Dairy Products Section Established

At the annual meeting of the Dairy Science Association held at Chicago in October, 1919, the following article was adopted as an Amendment to the Constitution of the Association.

Organization of Divisions and Sections

Article II. Professional groups based on specialized interests to be known as sections of the Society and to be formed by not less than ten active members be authorized by the executive committee when considered for the best interests of the Association.

Such sections may elect their own officers and make any rules for their own guidance not inconsistent with the constitution and by-laws of the Association.

Pursuant to this article the Dairy Products Section was established and at the annual meeting held at Chicago in October 1920, the following officers were elected. Roy C. Potts, chairman; A. W. Rudnick, secretary.

In order that a list of the members of the Section may be established, those members of the Association who desire to be considered as members[1] of the Dairy Products Section should forward their names and addresses immediately to the Secretary with the following information: (1) Present title and official position, (2) Major line of dairy work in which you are engaged, (describe fully); (3) Specific phases of dairy products work in which you are interested, (4) What in your opinion is the purpose of this section? (5) Should this Section have a definite program of work? (6) What should this program include? (7) What subject of dairy products is of foremost importance and should be first considered by this section? (8) Should the program of this section at the next annual meeting be devoted to a full and comprehensive consideration of the subject, "Practical Methods of Improving the Quality of Dairy Products?"

Roy C. Potts,
Chairman.
A. W. Rudnick,
Secretary.

[1] Prompt response from members of the Dairy Science Association who desire to be considered as members of the Dairy Products Section, is requested.—Chairman.

What is the Purpose of the Dairy Products Section of the American Dairy Science Association?

At the meeting of the Dairy Science Association, held at Chicago in October, 1920, the writer was elected chairman of the Dairy Products Section, and Professor A. W. Rudnick was elected secretary of that Section. There are at least twenty-five or more members of the Association who profess to have a deep interest in the dairy products phase of the dairy industry. Thus this section is composed of a body of men capable of giving consideration to the problems connected with the manufacture and marketing of dairy products, including every investigational, commercial and economic aspect of the subject.

The Dairy Products Section undoubtedly was established for a definite purpose and that purpose contemplated something more than a "sectional talk-fest" at each annual meeting.

Since receiving notice of my election to the chairmanship of this Section, I have given considerable thought to what that "contemplated something" should be and how it could best be attained. There are many ways in which that "contemplated something" may be expressed, but in simple terms it may be defined as, "The study of specific problems and the devising of definite aids to the manufacturing and marketing of dairy products." (If this is not correct, will others express their views and set us right?)

Assuming that the purpose has been stated correctly, we may next inquire, "What specific problems should be studied and what definite aids are most needed?" Another question immediately arises, "How should these problems be studied and how should the aids be worked out and their practical utility and value determined?"

It is quite logical to consider this latter question first, for the problems will never be solved by this Association until a plan of attack is formulated,—until a program of action is determined upon. And a definite program of action in my opinion is the greatest need of the American Dairy Science Association. The Association may have one, but if it has, it has never been brought to my attention.

In formulating a program of action for the Dairy Products Section, the writer desires the help of every member of that Section. The program devised should not be for one year only, but, if possible, for several years.

The answer to the question "How shall dairy products problems be studied?" has been indicated, and that answer definitely stated is, "Ac-

cording to a definite, well planned program of action." Among the various problems which should be studied the following are mentioned:

1. Practical grades and standards for use in buying cream for butter making purposes. (The writer questions the existence of such grades at the present time.)

2. Practical commercial market grades for milk. (At present there are many grades, most of which are impracticable for use as commercial grades.)

3. State and federal regulation of quality labels on dairy products. (Such regulation may be considered necessary to promote the marketing of dairy products on a quality basis.)

4. Increased efficiency in marketing dairy products. (Are producers' marketing organizations a step toward increased efficiency?)

5. Essential dairy marketing statistics. (What comprise such statistics and how can they best be made available to the industry?)

6. National advertising of dairy products. (Is such possible and what conditions are necessary for its success?)

The foremost problem of the dairy industry is that of improved quality in our dairy products. In an article in the next issue of the JOURNAL, this subject will be discussed and a suggested plan of solution of this problem presented. Is that plan practicable? Can the Dairy Products Section of the American Dairy Science Association suggest a practical plan or can it aid in working out a practical plan for the solution of that question? If the plan suggested in the article referred to above is not practicable, the Forum offers a medium for the exchange of ideas whereby a practical program of action for the solution of that problem by the Dairy Products Section may be discussed. Why should not the members of the Dairy Products Section use the Forum for that purpose?

ROY C. POTTS,
Chairman of Dairy Products Section.

BOOK REVIEW

The American Home Diet. Dr. E. V. McCollum and Nina Simmonds. Frederick Mathews Company, Detroit, Michigan.

In this book the authors have set forth in very clear and simple language which every reader can understand, the application to the modern American diet of the newer principles of nutrition that have been evolved during the past few years.

No greater tribute can be paid the authors than to say that it is essentially a mother's book, whose aim it is to point out specifically what constitutes a safe and wholesome diet and to simplify the mother's work in planning and providing such a diet for her family.

In order best to give the reader an appreciation of these newer principles of nutrition and their relation to health, there is a simple discussion on the relation of diet to health and the alarming increase of old age diseases and their prevention to a large extent through correct diet. Deficiencies in certain groups of foods and how these can be offset by combining with other groups not deficient in that particular food requirement, is clearly set forth. The dietary properties of the more important American foodstuffs, and their values, as well as their deficiencies, are pointed out. The value of leafy vegetables and milk and milk products as protective foods is especially emphasized. A chapter is devoted to the discussion of dangerous foods and the proper care of foods in the home. There is also a chapter devoted to the feeding of young children.

The second part of the book contains a set of menus for every day of the year. In these menus the right combination of seasonal foods and correct methods of preparation are exemplified, thus saving the housewife's time in planning the meal. A number of recipes are also included, although the authors lay no claim to having written a cook book.

In the light of the newer discoveries in the field of human nutrition this book is a corner stone upon which to build a healthier, happier and more virile American life.

J. H. F.

STUDIES ON CONFORMATION IN RELATION TO MILK PRODUCING CAPACITY IN CATTLE[1]

II. The Personal Equation of The Cattle Judge

JOHN W. GOWEN

Biological Laboratory, Maine Agricultural Experiment Station, Orono, Maine

Progress of the dairy cattle industry depends in the last analysis on men. If these men are gifted with that supernatural power by which they can choose the best from the best, progress toward the desired goal will be rapid. But should these men be misfits, ever making the undesirable choice, progress will be nil or worse. It is the man equation which counts.

The history of dairy cattle breeding is honeycombed with the personal equation of the men who laid the foundation of our modern industry. It is in fact to the combined ideals of the breeder and showman of the past that we owe the form and conformation of the cattle of today. As originally conceived these ideals naturally varied. The animal, at first taken as a whole, came more and more to be regarded as composed of parts, each with a definite function. As a further development it became evident that these functions were co-related and that conformation of one part of the body might indicate the functioning of another part. The paramount importance of determining these co-relations between body conformation and milk yield was recognized early. Point by point the characters of the good cow as distinguished from the poor producers were picked out and segregated in men's minds. Their origin was diverse, one appearing in this community, the other appearing miles away. In its earliest beginning in the eighteenth century, we owe one of the first points of cattle judging to an obscure section of Scotland;

[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 140.

later the Jersey Isle contributed others, and the Frenchman, Guénon, called attention to the escutcheon. Thus to each dairying locality is the modern dairyman indebted for some information on the selection of dairy animals. Most of the points were passed down from generation to generation by word of mouth. In this stage the ideas were plastic, being shifted for truth and molded in form by each generation. It is to Le Contour that we owe the collection and rounding out of the early ideas into a complete whole. He did his work well, for, if we examine the score card of the show ring or the text book, little visible change has been made from that which he originally published save in the most minor points.

Today we are face to face with much the same problem that Le Contour tried to solve with his score card. The opportunities for progress are better, however. Whereas in his day the milk scales were almost unknown, today they are so common and inexpensive that some sort of record should be available for most cows. Dependence no longer need be placed in the judgment of the man in determining the best from the poorest. Unfortunately the wily craftsman from whom it is sometimes necessary to buy has shaken the confidence in such records, unless they are certified by some such means as the advanced registry. The problem consequently becomes nearly as acute as in the former days when lack of instruments made conformation the basis of most selection of dairy cattle. Analytically considered, however, the dairy cattle industry is in a more advantageous position. In the days of its beginning the points of conformation were not subject to any adequate test of their validity both because of the lack of suitable records and because of the lack of proper methods. Naturally many spurious points with little or no relation to milk yield made their appearance among the truly legitimate characters by which the good cows with adequate production at the pail could be selected from the poor producers. Today both the data and the methods are available to properly test the true worth of the points of conformation.

The American Jersey Cattle Club has collected a large series of data on the scores of cows making their advanced registry.

These records have been made available for analysis by this laboratory through the kindness of Mr. Gow.[2] These records have already been analyzed[3] to show the value of the different points as indicators of the cow's ability in the 365-day test. Briefly the points of conformation which bear more particularly on milk yield are the total score of the cow or what might be called the cow taken as a whole; the character, size and elasticity of milk veins; the size and quality of the whole udder; the size of the rear udder; the shape and size of the paunch; the general appearance of the cow; the thighs flat and well cut out, and the length of the rump. The other points are of such small worth as indicators of the milk producing capacity of the cow that they may be neglected without any appreciable error.

It was further shown that if we compare the relative worth of conformation as a whole (total score) or of any of the individual points as a measure of 365-day milk yield with a milk yield of short duration as a measure of the 365-day production it is found that a milk record of Holstein-Friesian cows even though it was only taken for seven days was about two and one-half times as good an indicator of the cow's ability as were any of the physical points of conformation.[4]

Pausing to consider briefly these facts we see that a seven-day test might be considered as an objective test whereas the value of the points on conformation are a subjective test for the cow's producing ability. That is, the seven-day test is simply dependent on the reading of the scales that weigh the milk, whereas

[2] The author wishes to express his personal appreciation for this cooperation.

[3] Gowen, John W., 1920. Conformation and its relation to milk producing capacity in Jersey cattle. Jour. Dairy Science, vol. iii, no. 1, 1–32.

[4] It may be argued that since these data are for advanced registry cattle they are not of general application. This may be true in part. In a comparison of the size and elasticity of milk veins with milk yield Aldrich and Dana (Aldrich, A.M., and Dana, J.W. 1917. The relation of the milk veins system to production. In Bul. 202, Vermont Agricultural Experiment Station, p. 1–24, fig. 3) showed essentially the same correlation coefficients on 600 cattle selected presumably at random which were shown in the author's former paper on scores of these organs and milk yield. Such being the case it would appear reasonable to suppose that the relations as above deduced from registry of merit cattle are not materially different from those actually found in dairy cattle as a whole.

the use of a scale of points to judge a cow for milk yield depends not on any external scale but on the mental processes or mental ability of the judge to so balance his cuts as to show the true worth of the cow. From this it follows that the conformation of the cow as a measure of milk yield would in all probability be subject to the personal bias of the judge. Analysis of the data on this point shows that such is in truth the case. In table 1 are given the constants for the average score and milk yield as calculated for each of the 19 different judges. These judges are selected to include those which had scored 25 or more cows with known milk yields. The probable errors are calculated by the ordinary method. It is realized that this method makes it subject to some error, causing the probable error to be too low in amount. The judges are indicated by a code number of this laboratory.

Examination of the mean score for each judge as given in table 1 shows that considerable difference of opinion exists. If this mean score is compared with milk yield, the differences become even more marked. Thus judge 1 gives his cows a score of 91.9 when these cows' average milk yield is 7645, whereas in the opinion of all the judges, cows of this milk yield should be scored only 90.1. Judge 58 gives cows whose milk yield was 7538 a score of only 85.5 on the average. If these two judges' opinions be compared it is seen that on cows of approximately the same milk yield they have a difference of 6.5 ± 0.6 points on score. Other comparisons bring out similar results. Where such differences exist there must be a corresponding diversity of opinion in the minds of judges of dairy cattle as to what score should be given to animals of a given milk yield. This, of course, does not say that the judges who score all of their cattle high for a given average of milk production are better judges of milk yield from conformation than those who score their cattle lower. In fact the reverse may be the case. The only difference is that the mental scale of the value of conformation for milk yield differs in men, causing the resulting score on cows of the same milk yield to be lower or higher in accord with the relative level of their mental scale. The judges 1 and 58 illustrate such a condition of affairs, judge 58

Jersey scorer 47

MILK (365 DAY YIELD)	TOTAL SCORE 100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	
139–129						1						1
129–119			1				1					2
119–109										1		1
109–99				1	2	1						4
99–89			2		2						1	5
89–79			3	1	1	2	1			1		9
79–69		2	1	2	1	2	1	1				10
69–59		1		3	1	7	3	1		1		17
59–49		1	1	4	3	4			1			14
49–39				2	1							3
39–29												
		4	8	13	11	17	6	2	1	3	1	66

Jersey scorer 51

MILK (365 DAY YIELD)	TOTAL SCORE 100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	
109–99				1	1				2
99–89					1				1
89–79			2	2	3				7
79–69				1		4		1	6
69–59				1	3	2			6
59–49					1	1			2
49–39				1					1
39–29									
			2	6	9	7		1	25

Scorer 52

MILK (365 DAY YIELD)	TOTAL SCORE 100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
109–99			1								1
99–89				1			1				2
89–79				1	2		1				4
79–69				2		3		1		1	7
69–59						3	1		1		5
59–49				1		2	2				5
49–39				1		1					2
39–29											
			1	6	2	9	5	1	1	1	26

Jersey scorer 58

MILK (365 DAY YIELD)	TOTAL SCORE											
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	
109–99						1					1	2
99–89					1			2		2		5
89–79					1						1	2
79–69						2	2			1		5
69–59					1	2	4				1	8
59–49							1		1	1		3
49–39									1			1
39–29												
					3	5	7	2	2	4	3	26

Jersey scorer 59

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
129–119				1	1						2
119–109				2	1						3
109–99						1					1
99–89				1		4	2				7
89–79					3	2	2	3			10
79–69				2	4	5	2			1	14
69–59				4	3	4			1		12
59–49						1		1			2
49–39											
39–29											
				10	12	17	6	4	1	1	51

Jersey scorer 76

MILK (365 DAY YIELD)	TOTAL SCORE												
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	78–76	
129–119			1										1
119–109													
109–99		1	2	1									4
99–89						2	1		1				4
89–79		1	1	2	3	2							9
79–69			1	1	2		2					1	7
69–59					1	1							2
59–49					1		3						4
49–39							1						1
39–29													
		2	5	4	7	5	7		1			1	32

scoring cattle actually though not significantly better for milk yield than judge 1, although no. 58 has a lower scale for scoring.

If the relative variation of score and milk yield between these different judges is studied, the high score is seen to be associated with high milk yield and low score with low milk yield. Thus even between these judges there remains after deducting the personal equation some association between milk yield and total

TABLE 1

Mean score and milk yield of Jersey registry of merit cattle as scored by nineteen different judges

SCORER	MEAN SCORE	MEAN MILK YIELD
1	91.9±0.2	7645±106
2	91.5±0.3	8095± 87
6	90 6±0 3	6905±143
20	91 8±0 4	8320±219
31	91.1±0.1	7847±108
33	92.0±0 2	8063±108
37	89 2±0.4	8245±192
47	90 4±0 3	7455±167
51	91.0±0 3	7580±194
52	89.2±0 4	7115±201
58	85.5±0 5	7538±215
59	89.4±0.3	8147±159
76	90 4±0.5	8156±210
80	91 7±0 4	7380±227
84	85.7±0.6	7833±153
89	91.8±0 4	8385±205
102	90 4±0 3	7144±160
117	87.2±0 4	7286±132
118	91.5±0.3	7000±107
Average........	90.1	7691

score. All correlations are very low and their probable errors so great, due to lack of numbers, that it is doubtful if comparisons between judges should be considered as more than indicative, however.

The amount of variation for the total score and amount of milk is shown for each of the judges in table 2.

No particular association is shown to exist between the variation of each judge in his total score and the variation of the cattle

he judged as to their milk yield. That is because one judge was scoring a group of cows highly variable in their milk yield it was no sign that his scoring of these cattle would show more variation than would the scores of a judge rating a group of cattle whose milk yield was less variable. In fact, it was equiprobable that the scores of the two judges would be equal in their variation.

TABLE 2

Standard deviations of total score and of milk yield for Jersey registry of merit cattle as scored by nineteen different judges

JUDGE	STANDARD DEVIATION SCORE	STANDARD DEVIATION MILK
1	3.66±0.16	1745±74
2	4.91±0.19	1576±62
6	3.30±0.24	1381±102
20	3.50±0.27	2024±155
31	2.48±0.10	1944±76
33	3.19±0.13	1908±76
37	3.76±0.25	2028±135
47	3.98±0.23	2011±118
51	2.19±0.21	1440±137
52	3.25±0.30	1521±142
58	3.87±0.36	1629±152
59	2.75±0.18	1678±112
76	4.14±0.35	1761±148
80	2.82±0.27	1681±160
84	5.67±0.43	1420±108
89	2.73±0.26	1552±145
102	3.24±0.20	1820±113
117	4.02±0.30	1264±93
118	2.95±0.19	1195±76
Average..............	3.50	1612

If comparison is made between the data of tables 1 and 2 it is clearly seen that each judge has his personal scale for judging cattle. Thus, if we compare the two judges 20 and 31 it is found that these judges scored groups of cattle quite similar in milk yield, in fact differing only by about one-twentieth of its total amount. The milk yields of the two groups of cows were nearly the same in variation. The average score in each case was practically the same but the score of judge 31 was about one-third less than the score of judge 20.

Some likenesses are shown to exist between the way in which the judges score different groups of cattle. Thus the judges who give the higher average scores to their cows have a less variation of their scores between cows than the judges who give their cattle lower scores even though the milk yields of these cows are more variable.

No particular relation exists between the average milk yield and the variation of the score.

TABLE 3

Correlation between score and milk yield for Jersey registry of merit cattle as shown by nineteen different judges

JUDGE	CORRELATION COEFFICIENT BETWEEN SCORE AND MILK
1	0.174±0.058
2	0.241±0.052
6	0.222±0.099
20	0.578±0.072
31	0.097±0.055
33	0.428±0.046
37	0.413±0.078
47	−0.098±0.082
51	0.228±0.128
52	0.205±0.127
58	−0 077±0.131
59	0.160±0.092
76	0.417±0.098
80	0.170±0.131
84	0.614±0.067
89	0.405±0.111
102	0.363±0.076
117	0.027±0.104
118	0.106±0.089
Average	0.246

The foregoing results all point to the conclusion that judges differ in the mental scale by which they judge cattle. It now remains to be shown if the mental scale of each judge is equally adequate in placing the different cows properly as regards milk yield and butterfat percentage. The data of table 3 furnish the information necessary for such a comparison.

Table 3 shows that of the nineteen men who judged different groups of Jersey registry of merit cattle nine clearly could judge

dairy cattle by the score card and select the better milkers, eight were mediocre judges, and two were worse than mediocre, giving the low producing cows better scores than the high producers. On the correlation scale the range of ability was large, from 0.614 to − 0.098. The average ability of this group of judges to score cattle for milk yield was 0.246. This is about 25 per cent better than is the judgment of the average trained dairy man as given for all cattle.

If these results are compared with those of tables 1 and 2 several interesting points appear. There is no relation between the average score given by each judge to his group of cows and the ability of that judge to score those cows for milk production. When it is noted that the mental scale of each judge differs considerably this fact is significant. It shows clearly why two equally good judges of cattle may place their cows several points apart, while at the same time they keep the cows in the relative order of milk yield.

The comparison of the mean milk yields of the different groups of cows as given in table 1 with the ability of the judges to score cattle as given in table 3 shows that the cows whose average milk yields are the larger are more easily judged for milk yield than are the groups of cows whose average milk yields are lower. Likewise, it is shown in tables 2 and 3 that the groups composed of cows with quite variable milk yields are more easily judged than are those groups of cows which have milk yields closely similar. It is furthermore shown that the men who can score cattle most accurately for milk yield tend to have their scores show more variation than do the men who cannot score cattle as well. There may be some effect of the kind of judges which score the two groups, the judge scoring the better group being more able than the judge scoring the lower yielding cows.

While other considerations enter into the judging of dairy cattle, its prime object is the selecting of the cows which will be good milk producers. As pointed out for table 3, only about one man in two can even approach doing this. Such being the the case, the individual man will do well before he relies entirely on his ability to select cattle by their conformation to make a

sufficient test to convince himself that he is one of those gifted men who can judge dairy cattle.

The average value of the ability of these nineteen judges to score cattle is only 0.246, measured in the correlation scales. While this indicates the points of conformation as worth something as a means of predicting milk yield, still it does not make them worth a great deal. If comparison is made between this figure and that for the relation of a milk yield of short duration (seven days) with the milk yield of the year period it is found that the milk yield is nearly two times as valuable as an indicator of milk production over the long period as is the conformation of the cow even though this conformation be judged by men of long experience. The further advantage of the short time test lies in the fact that almost anyone can weigh milk. No personal equation need be present in recording the weights. Such being the case, when accurate records are obtainable the dairymen or buyer would do well to consider the milk yields carefully in selecting dairy cows.

Appendix Tables

Correlation tables of milk yield and total score for each judge; Jersey registry of merit cows*

Jersey scorer 1

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
149–139			1								1
139–129											
129–119	1				1						2
119–109				1	1						2
109–99		1	2	1	2	1					7
99–89		1	5	2		2		1			11
89–79		2	6	6	2		2	1			19
79–69			7	9	8	8	1	2			35
69–59		2	7	5	4	7	2			3	30
59–49	1	1	3	2	2	1	2				12
49–39		2			1		1		1		5
39–29											
	2	9	31	26	21	19	8	4	1	3	124

* 365 day milk yield given in thousands.

Scorer 2

MILK (365 DAY YIELD)	TOTAL SCORE															
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	78–76	76–74	74–72	72–70	
139–129					1											1
129–119																
119–109	1		3	1	1											6
109–99		3	2	1	1											7
99–89	4	2	6	5	4	1	6	1		2						31
89–79	2	7	5	3	2	1	1	3	1	1						26
79–69	1	7	3	5	9	2	7	1		2						37
69–59		1	5	3	4	4	2	8		2		1				30
59–49			3	2	1			3								9
49–39		1														1
39–29																
	8	21	27	20	23	8	16	16	1	7		1				148

Jersey scorer 6

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
109–99				1	1						2
99–89				1	1						2
89–79			3								3
79–69			1	2	2	4	1				10
69–59			1		5	4	1			2	13
59–49			3	2	1	3	2				11
49–39						1					1
39–29											
			8	6	10	12	4			2	42

Scorer 20

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
149–139			1							1
139–129										
129–119										
119–109		2	1		1					4
109–99			1	2	1					4
99–89				1						1
89–79		1	4	4			1			10
79–69			3	2		2		1		8
69–59					2	2	2		1	7
59–49					1	1	2			4
49–39										
39–29										
		3	10	9	5	5	5	1	1	39

Jersey scorer 31

MILK (365 DAY YIELD)	TOTAL SCORE								
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	
169–159				1					1
159–149									
149–139			1						1
139–129									
129–119				1	1				2
119–109			1	2	2				5
109–99			2	2	1	2	1		8
99–89			2	4	7	6	3		22
89–79			2	2	7	4	3		18
79–69		1	6	7	8	8		3	33
69–59			2	13	8	9	4		36
59–49			1	5	6	4	2		18
49–39				1	2				3
39–29									
		1	17	38	42	33	13	3	147

Scorer 33

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
149–139			1	1						2
139–129										
129–119			2	2						4
119–109		1	1		1					3
109–99		4	4	1	1	1				11
99–89		3	3	5	3	3	1			18
89–79		1	5	13	8	1	2			30
79–69		2	6	5	8	5	1		1	28
69–59		2	3	9	7	7	2	1	1	32
59–49			1	2	1	3	2	1		10
49–39					1			1	1	3
39–29								1		1
		13	26	38	30	20	8	4	3	142

Jersey scorer 37

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
149–139							1				1
139–129											
129–119		1									1
119–109				3		1					4
109–99			1	1	1				1		4
99–89		1		1	1	1	2				6
89–79					2	4		1			7
79–69			1	1	7	1	1	2			13
69–59					2	2	1	2	1	1	9
59–49					1	1	2			2	6
49–39											
39–29											
		2	2	6	14	10	7	5	2	3	51

Scorer 80

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
139–129				1						1
129–119										
119–109										
109–99										
99–89				1						1
89–79		1	2	1	1				1	6
79–69			1	1		2				4
69–59				4	3	1	1			9
59–49				1	3					4
49–39										
39–29										
		1	3	9	7	3	1		1	25

Jersey scorer 84

MILK (365 DAY YIELD)	TOTAL SCORE															
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	78–76	76–74	74–72	72–70	
119–109		1														1
109–99						1										1
99–89			2	1	1	1		1		1						7
89–79		1				4	1	1								7
79–69					2		1	1	2	2	2	1				11
69–59					1			1	4	3					1	10
59–49									1							1
49–39										1						1
39–29																
		2	2	1	4	6	2	4	7	7	2	1			1	39

Scorer 89

MILK (365 DAY YIELD)	TOTAL SCORE								
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	
119–109				1					1
109–99			1		1				2
99–89			2	3	3				8
89–79		1	1	2		1			5
79–69			1			2		1	4
69–59				1	1	1	1		4
59–49					2				2
49–39									
39–29									
		1	5	7	7	4	1	1	26

Jersey scorer 102

Milk (365 day yield)	Total score									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
149–139			1							1
139–129										
129–119										
119–109					2					2
109–99										
99–89		1	1	3						5
89–79				1	3	1				5
79–69			2	5	2	3	2	2		16
69–59				3	3	1	2	1	1	11
59–49			1	2	5	1	4	4		17
49–39				1	1					2
39–29										
		1	5	15	16	6	8	7	1	59

Scorer 117

Milk (365 day yield)	Total score										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
109–99				1					1		2
99–89					1		1				2
89–79			1	1		1		3			6
79–69					1	2	1	3	5	1	13
69–59			1	2	3		2	2	1	2	13
59–49				1		2	1	1	1		6
49–39											
39–29											
			2	5	5	5	5	9	8	3	42

Jersey scorer 118

Milk (365 day yield)	Total score									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
109–99			1							1
99–89					1	1				2
89–79			2	2	1	1	1			7
79–69			6	6	1	2	1	2		18
69–59			1	5	5	1		1	1	14
59–49			2	3	4	5				14
49–39										
39–29										
			12	16	12	10	2	3	1	56

THE PROTEINS OF COTTONSEED MEAL[1]

I. AMINO ACID CONTENT

W. B. NEVENS

From the Department of Animal Husbandry, University of Illinois, Urbana

I. INTRODUCTION

One of the earliest references to the proteins of cottonseed meal was made by Ritthausen (1), who separated the proteins in the form of spheroids. Osborne and Voorhees (2) isolated a protein from cottonseed meal which had the nature of a globulin, being soluble in salt solutions, and comprised 42.3 per cent of the total nitrogen of the meal. Another protein (or proteins) was found to be insoluble in salt solutions but soluble in 0.2 per cent potash solution and amounted to 44.3 per cent of the total nitrogen of the meal. Two per cent of the total nitrogen was present in the form of water soluble proteose.

TABLE 1

Percentage of nitrogen in the different groups in various proteins

SOURCE	N AS AMMONIA	BASIC N	NON-BASIC N	N IN MgO PRECIPITATION	TOTAL N
Globulin, cottonseed	1.92	5.71	11.01		18.64
Globulin, wheat	1.42	6.83	9.82	0.28	18.39
Zein, maize	2.97	0.49	12.51	0.16	16.13
Hordein, barley	4.01	0.77	12.04	0.23	17.21

The distribution of nitrogen in various protein bodies was studied exhaustively by Osborne and Harris (3), who employed the modified Hausmann method (4). The following values are typical of their results.

[1] The results presented in this paper formed part of a thesis submitted to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Husbandry.

These investigators state that "This wide variation in the proportion of basic decomposition products of the various proteins . . . . raises important questions regarding their food value." Osborne (5) further found that the basic nitrogen of the globulin of cottonseed, as determined by precipitation with phosphotungstic acid, consisted of 3.46 per cent histidine, 13.51 per cent arginine and 2.06 per cent lysine.

The content of the mono-amino acids of the "edestin" of cottonseed meal was determined by Abderhalden and Rostoski (6) by the use of the Fischer ester method (7), and is as follows, calculated for dry, ash free edestin of cottonseed:

	per cent
Glycocoll	1.2
Alanin	4.5
Amino valerianic acid	Present
a-proline	2.3
Leucin	15.5
Glutamic acid	17.2
Aspartic acid	2.9
Phenyl alanin	3.9
Serin	0.4
Tyrosin	2.3
Tryptophane	Present

The quantitative determination of the amino acids of feedingstuffs by means of the Van Slyke method (8) was undertaken by Grindley and his co-workers (9), and a little later by Nollau (10). In Nollau's procedure, samples of the finely ground feeds were hydrolyzed with 20 per cent hydrochloric acid until the content of amino acid, as determined by the Van Slyke method, became constant. The material insoluble in hydrochloric acid was filtered off, the clear extract concentrated under diminished pressure and made up to a certain volume. The total nitrogen content of this extract was used as a basis for calculating the final results. In a report of the subsequent work of Grindley and co-workers (11), it is claimed that since Nollau filtered off the solid residue after hydrolysis of the feedingstuff and before making his total nitrogen determinations upon which the final calculations were based, that his results are not accurate since a part of the total nitrogen was undoubtedly discarded in the solid residue.

The heats of combustion of several vegetable proteins were carefully determined by Benedict and Osborne (12). The globulin of cottonseed was found to yield 5596 calories per gram, compared to 5358 calories per gram for the globulin of wheat and 5916 calories per gram in the case of the hordein of barley. In commenting upon their determinations, the investigators state that "many irregularities. . . . appear, which are doubtless due to the different proportion of the various amino acids which constitute the molecules of the different proteins."

It is evident from the foregoing discussion that our knowledge of the composition of the proteins of cottonseed meal is very incomplete. The globulin is the only protein of cottonseed which has been isolated in pure form and whose composition has been determined. The globulin, however, according to Osborne and Voorhees, contains only 42.3 per cent of the total nitrogen of the cottonseed. The character, identity and chemical composition of the remaining proteins are practically unknown, and it is evident from the data given above that our knowledge of the distribution of the nitrogen in the proteins of cottonseed meal is very meager indeed. The investigation of the distribution of the nitrogen in the proteins of cottonseed meal therefore constituted the object of this study.

II. METHODS EMPLOYED IN CHEMICAL ANALYSIS[2]

The method of analysis employed consisted of two main procedures. The first consisted of a series of extractions whereby the nonprotein together with a very small amount of protein was first removed, and following this, the proteins were extracted from the residual matter of the sample which consisted mostly of fiber. The second main procedure embraced the hydrolysis of the extracted proteins, and the analysis of the resulting solution

[2] The method of procedure here outlined is one which has been developed and perfected in this laboratory by Dr. H. S. Grindley, Mr. T. S. Hamilton and associates (9, 11, 33, 36 and unpublished manuscripts). The method of extraction preliminary to hydrolysis of the proteins has been developed entirely in this laboratory, while the actual determination of the nitrogen in the different groups follows closely the method of Van Slyke, but includes modifications perfected in this laboratory.

for certain amino acid and other groups according to the general method of Van Slyke (8).

The sample of cottonseed meal was prepared from good quality commercial meal, finely ground and passed through a 40-mesh sieve. Each sample taken for analysis weighed 15 grams and contained 1.0194 grams of nitrogen, or about 6 grams of protein.

In the first three extractions, which were carried out consecutively, cold anhydrous ether, cold absolute alcohol and cold 1.0 per cent trichloracetic acid were used. The samples of feeding stuff were placed in 500 cc. centrifuge bottles and 100 to 200 cc. of the reagents added. The bottles were placed on a shaking machine which rolled them back and forth continually. Usually two extractions were made each twenty-four hours, one extraction period being seven to eight hours and the other 15 to 16 hours in length. At the end of the extraction period, the sides of the bottles were washed down with the reagent, the bottles centrifuged and the clear supernatant liquid decanted. Usually six or seven extractions with each reagent were necessary.

The ether and alcohol extracts were filtered and any residues returned to the centrifuge bottles. After slight acidification with sulphuric acid, the ether and alcohol were evaporated and recovered and total nitrogen determinations made on the residue. The small amount of protein removed in the trichloracetic acid extracts was recovered by precipitation with colloidal ferric hydroxide (containing 5 per cent Fe_2O_3) in boiling solution. The precipitate was transferred to a digestion flask with 20 per cent hydrochloric acid, and total nitrogen determined in the filtrate.

The bulk of the proteins was removed from the residue remaining after extraction with 1.0 per cent trichloracetic acid by extraction, first, with dilute sodium hydroxide solution, then with 20 per cent hydrochloric acid followed by treatment with 5 per cent sodium hydroxide solution. The dilute sodium hydroxide solution used during the shorter period was a 0.2 per cent solution and that during the longer period a 0.1 per cent solution. These extracts were neutralized, acidified with hydro-

chloric acid and concentrated in vacuo to a small volume. An equal volume of concentrated hydrochloric acid was then added. The residues remaining after treatment with dilute sodium hydroxide solution were boiled for three minutes with 20 per cent hydrochloric acid. After cooling, the solution was filtered off, the residue washed and the procedure repeated once. The washings were evaporated to a small volume, an equal volume of concentrated hydrochloric acid added and the washings then combined with the main hydrochloric acid extract. The residues insoluble in hydrochloric acid were treated three times with 5 per cent sodium hydroxide solution using centrifuge bottles as in former extractions. After washing the residues nearly free from alkali, they were submitted to Kjeldahl analysis. The extracts and washings were acidified with hydrochloric acid, concentrated in vacuo and transferred to digestion flasks with an equal volume of concentrated hydrochloric acid.

The proteins precipitated by colloidal iron and the proteins removed by extraction with dilute sodium hydroxide, 20 per cent hydrochloric acid and 5 per cent sodium hydroxide were completely hydrolyzed by boiling for fifteen hours upon a combined electric plate and sand bath under reflux condensers. The resulting solutions were combined and analysis for the chemical groups characteristic of certain amino acids executed essentially as directed by Van Slyke (8), but with the use of minor improvements perfected in this laboratory.

III. DISCUSSION OF RESULTS

The results obtained by application of the method of chemical analysis outlined in the preceding section to eight portions of the same original sample of cottonseed meal are shown in the accompanying tables 2 and 3. Table 2 shows the values expressed in percentage of the total nitrogen present in the sample of feeding stuff when it was taken for analysis, while table 3 shows the same values expressed in percentage of the feeding stuff itself.

Two averages are included in the tables. The first is compiled by taking the average of all values obtained by analysis of the entire eight samples. The second average is obtained by

TABLE 2

Summary of the results of analysis of the proteins of cottonseed meal

(Results expressed in percentage of the total nitrogen in sample)

SAMPLE NUMBER	NONPROTEIN NITROGEN				RESULTS OF THE VAN SLYKE ANALYSIS										UNCHARACTERIZED NITROGEN LOST IN METHOD OF ANALYSIS						TOTAL
	Soluble in absolute ether	Soluble in absolute alcohol	In filtrate from colloidal iron	Total nonprotein nitrogen	Insoluble humin nitrogen	Soluble humin nitrogen	Ammonia nitrogen	Arginine nitrogen	Cystine nitrogen	Histidine nitrogen	Lysine nitrogen	Amino nitrogen in filtrate from the bases	Non amino N in filtrate from the bases	Nonprotein N + results of Van Slyke analysis	Insoluble in strong alkali	Unadsorbed humin (filtered from solution during decomposition of phosphotungstate precipitate)	Soluble in amyl alcohol-ether mixture	In residue from solution of the bases	In residue from solution of the filtrate from the bases	Total nitrogen lost	Total nitrogen accounted for
C1	0.021	0.570	4.943[2]	5.534	2.609	3.462	9.455	18.569	0.961	6.095	3.871	38.495	4.079	93.130	0.220	2.403	0.906	0.206	0.017	3.752	96.992
								18.775	0.961	4.876	4.609	41.466	2.463	94.210		2.145	1.043	0.206	0.055	3.669	97.879
C2	0.089	0.618	4.870[2]	5.577	2.609	5.117	9.689	18.981	0.821	5.622	3.625	39.646	3.908	95.595	0.260	2.042	0.734	0.103	0.027	3.166	98.761
								19.119	0.983	7.038	2.494	41.432	2.955	97.013		1.081	1.078	0.326	0.051	2.796	99.809
C3	0.202	0.652	5.053[2]	5.907	2.492	5.459	9.929	18.295	1.035	7.966	3.471	39.157	2.348	96.062	0.302	1.867	0.614	0.240	0.079	3.102	99.164
								18.638	1.101	7.120	3.668	38.546	1.454	94.314		1.448	0.961	0.200	0.133	3.044	97.358
C4	0.109	0.614	5.531[1]	6.254	2.623	4.477	8.892	19.160	1.285	6.441	4.430	39.828[a]	0.161	93.551	0.233	3.011	0.841	0.243	0.130[a]	4.458	98.009
								17.635	0.961	8.038	4.510	39.828	0.161	93.379	—[b]	3.076	1.428	0.247	0.130	5.114	98.493
C5	0.081	0.506	5.245[1]	5.832	2.981	2.415	9.249	18.701	1.051	6.987	5.042	41.659	2.784	96.701		1.230	0.645	0.255	0.217	2.777	99.478
								16.339	1.051	10.181	3.881	42.257	2.577	96.763		1.153	0.736	0.601	0.082	3.002	99.765

C6	0.129	0.489	5.722[1]	6.340	2.930	2.650	9.318	19.580	0.963	6.568	4.780	41.659	2.504	97.292	0.685	1.021	0.642	0.445	0.096	2.889	100.818
								19.305	0.933	6.163	5.216	42.141	2 076	97.072		1 016	0.917	0.315	0.096	3.029	100.101
C7	0.081	0.420	6.097[1]	6.598	2.763	2.334	9.002	17.932	0.692	9.627	3.503	39.131	2 921	94.503	0.719	0.818	0.994	0.068	0.054	2.653	97.156
								18.041	0.722	9 074	3.697	39.276	3.253	94 760		0.725	1 057	0.124	0.076	2.701	97.461
C8	0.047	0.506	7.012[1]	7.564	2.772	2.746	9.764	19 799	0.810	5.657	5.845	43 023	3 095	101.076	0 589	1.384	1.049	0.151	0.054	3.227	104.303
								20.404	0.751	7.271	4.702	43.939	3 812	103 726		1.343	1 087	0.115	0 082	3.216	106.942
Average[3]..	0.095	0.547	5.559[1]	6.201	2.772	3 582	9.412	18.705	0 943	7.170	4.209	40.718	2.535	96.197	0.430	1.610	0.921	0.240	0 086	3.287	99.484
Average[4]..	0.125	0.545	5 436[1]	6.106	2.699	3.890	9.485	18.736	0 906	7.397	3.807	40 124	2 677	95.827	0.492	1.252	0 875	0.228	0.076	2.923	98.750

[a] Determination lost. Value from other half of sample substituted.

[b] Determination lost. Average of 7 determinations used.

[1] After first precipitation.

[2] After second precipitation.

[3] Average of all determinations.

[4] Average of complete samples C2, C3, C6, C7.

TABLE 3

Summary of the results of analysis of the proteins of cottonseed meal

(Results expressed in percentage of the feeding stuff)

Sample number	Nonprotein nitrogen				Results of the Van Slyke analysis									Uncharacterized nitrogen lost in method of analysis					Total	
	Soluble in ether	Soluble in absolute alcohol	In filtrate from colloidal iron	Total nonprotein nitrogen	Insoluble humin nitrogen	Soluble humin nitrogen	Ammonia nitrogen	Arginine nitrogen	Cystine nitrogen	Histidine nitrogen	Lysine nitrogen	Amino nitrogen in filtrate from bases	Non amino nitrogen in filtrate from bases	Insoluble in strong alkali	Unadsorbed humin (filtered from solution during decomposition of phosphotungstate precipitate)	Soluble amyl alcohol-ether	Residue from solution of bases	Residue from solution of filtrate of bases	Nonprotein N + results of Van Slyke analysis	Total nitrogen accounted for
C1	0.0014	0.0387	0.3360[2]	0.3761	0.1769	0.2352	0.6426	1.2620	0.0653	0.4142	0.2631	2.6157	0.2773	0.0150	0.1633	0 0616	0.0140	0.0012	6 3284	6.5835
								1.2760	0.0653	0.3314	0.3133	2.8180	0.1674		0.1458	0.0709	0.0140	0.0037	6.4022	6.6516
C2	0.0061	0.0420	0.3310[2]	0.3790	0.1773	0.3478	0.6585	1.2900	0.0558	0.3821	0.2464	2.6940	0.2656	0.0177	0.1388	0.0499	0 0070	0.0019	6.4966	6.7119
								1.2993	0.0668	0.4783	0.1695	2.8153	0.2009		0.0735	0.0733	0.0222	0.0035	6.5928	6.7830
C3	0.0137	0.0443	0.3435[2]	0.4015	0.1694	0.3710	0.6748	1.2433	0.0703	0.5414	0.2360	2.6610	0.1596	0.0205	0.1269	0.0418	0.0163	0.0054	6.5283	6.7392
								1.2666	0.0748	0.4839	0.2493	2.6193	0.0988		0.0985	0.0653	0.0136	0.0091	6.4094	6.6164
C4	0.0075	0.0417	0.3759[1]	0.4250	0.1783	0.3043	0.6043	1.3021	0.0873	0.4377	0.3011	2.7067[a]	0.0110	0.0158	0.2046	0.0572	0.0165	0 0089[1]	6.3579	6.6609
								1.1985	0.0653	0.5462	0.3065	2.7067	0.0110		0.2091	0.0971	0.0168	0.0089	6.3462	6.6939
C5	0.0055	0.0345	0.3563[1]	0.3963	0.2026	0.1641	0.6286	1.2709	0.0715	0.4749	0.3427	2.8310	0.1892	—[b]	0.0836	0.0439	0.0173	0.0147	6.5718	6.7605
								1.1104	0.0715	0.6919	0.2638	2.8715	0.1751		0.0784	0.0500	0.0409	0.0056	6.5758	6.7799

C6	0.0088	0.0332	0.3889[1]	0.4309	0.1991	0.1801	0.6333	1.3306	0.0655	0.4464	0.3249	2.8310	0.1702	0.0465	0.0694	0.0437	0.0302	0.0065	6.6120	6.8083
								1.3120	0.0635	0.4188	0.3545	2.8630	0.1411		0.0691	0.0623	0.0215	0.0065	6.5963	6.8022
C7	0.0055	0.0285	0.4144[1]	0.4484	0.1878	0.1586	0.6118	1.2186	0.0471	0.6543	0.2381	2.6590	0.1986	0.0489	0.0556	0.0675	0.0047	0.0037	6.4223	6.6028
								1.2260	0.0491	0.6167	0.2513	2.6690	0.2211		0.0493	0.0719	0.0084	0.0052	6.4398	6.6235
C8	0.0032	0.0344	0.4765[1]	0.5140	0.1884	0.1866	0.6635	1.3456	0.0551	0.3845	0.3972	2.9235	0.2104	0.0400	0.0941	0.0713	0.0103	0.0037	6.8689	7.0883
								1.3866	0.0511	0.4942	0.3196	2.9860	0.2591		0.0913	0.0739	0.0078	0.0056	7.0492	7.2678
Av[3]	0.0065	0.0372	0.3778	0.4214	0.1849	0.2434	0.6396	1.2712	0.0641	0.4873	0.2861	2.7669	0.1723	0.0292	0.1095	0.0626	0.0163	0.0059	6.5374	6.7[illegible]09
Av[4]	0.0085	0.0370	0.3695	0.4150	0.1834	0.2644	0.6446	1.2733	0.0616	0.5027	0.2588	2.7265	0.1820	0.0334	0.0851	0.0595	0.0155	0.0052	6.5123	6.7110

[1] After first precipitation.

[2] After second precipitation.

[3] Average of all determinations.

[4] Average of complete samples C2, C3, C6, C7.

[a] Determination lost. Value for other half of sample substituted.

[b] Determination lost. Average of seven determinations used.

averaging the results secured in the analysis of the complete samples C2, C3, C6 and C7. It is believed that the latter average more nearly expresses the actual composition of the commercial cottonseed meal used, for the following reasons: (a) These samples, i.e., C2, C3, C6 and C7 show the best agreeing results throughout. The two parts of sample C1 agree well in the amount of arginine nitrogen, but show a considerable difference in the amounts of amino nitrogen, non-amino nitrogen and histidine nitrogen. The totals of the nonprotein nitrogen plus the protein nitrogen are considerably below the average of all the samples. In sample C4 the non-amino nitrogen is particul rly low, this value being one of the principal factors contributing to the noticeably low nonprotein plus protein of this sample. Sample C5 is omitted from the average partly on account of the non-agreement of its arginine nitrogen and histidine nitrogen values. Of the latter values, one is 3 per cent above the average of all samples. (b) The second average, i.e., of samples C2, C3, C6 and C7, includes values which are most free from obvious errors. In making the determinations in the case of sample C4, two determinations were lost, and in the case of sample C5, one determination was lost. While the results obtained for sample C8 agree fairly well throughout with themselves and with the average, the results are consistently high, and it is excluded from this average on the grounds of the totals obtained, which are obviously too high.

Nonprotein nitrogen. The first section of tables 2 and 3 shows the amount of nitrogen removed in the preliminary extractions with absolute ether, absolute alcohol and trichloracetic acid. While the absolute ether in the cold is used primarily to remove the lipins, such as the oils, waxes, etc., it also dissolves various amounts of other substances, such as coloring matters, and at the same time a small amount of nitrogen. The thorough extraction with absolute alcohol following the treatment with absolute ether presumably completes the extraction initiated by ether. The alcohol removes somewhat more nitrogen than the extraction with ether. The bulk of the nonprotein nitrogen accounted for, about 89 per cent of the total, remains, however, in the tri-

chloracetic acid extracts after precipitation of the proteins by colloidal ferric hydrate and the removal of the precipitate by filtration. That the nitrogen determined in these latter extracts is not protein nitrogen is apparent from the work of Van Slyke, Vinograd, Vilchur and Losee (13), Hill (14), Wolff (15), and others.

It seems from the study of the character of the nonprotein nitrogenous constituents of feedingstuffs by Grindley and Eckstein (16) that the forms of nitrogen represented in this classification consist principally of those forms naturally resulting from the cleavage of the proteins upon hydrolysis and therefore could not interfere in the determination of the characteristic chemical groups of the proteins were they not removed in the preliminary extractions. Neidig and Snyder (17), who recently determined the proportion of nitrogen in the form of ammonia in the ether extracts and alcohol extracts of different kinds of silage, found that from 28.1 per cent to 100 per cent of the ether extract nitrogen consists of ammonia nitrogen, while from 14.2 per cent to 23.4 per cent of the alcohol extract nitrogen is yielded as ammonia nitrogen. This indicates that only a part of the nitrogen soluble in ether and alcohol would appear in the ammonia fraction were it not removed previous to hydrolysis. Therefore, the removal of the nonprotein nitrogen at this point avoids possible complications in the further prosecution of the analytical procedure, and it is believed that the accuracy of the further determinations has been increased over that of previous methods by the removal of the nonprotein nitrogen before hydrolysis of the proteins. The total amount of the nonprotein nitrogen present in cottonseed meal found by the method used amounted to 6.106 per cent of the total nitrogen contained in the feedingstuff.

Results of the Van Slyke analysis. It is a matter of common knowledge that one of the important sources of loss in the analysis of proteins by methods involving the employment of acid hydrolysis is the formation of an insoluble black substance called humin. The term melanin is also applied to this substance, on account of its supposed relationship or similarity to the

naturally occurring body pigments. The amount of humin formed in acid hydrolysis of the proteins is greatly increased by the presence of carbohydrates, as shown by Gortner and associates (18, 19), Hart and Sure (20), and Osborne, Van Slyke, Leavenworth and Vinograd (21). A part of the humin formed, however, remains in solution in the hydrochloric acid, and is termed soluble humin.

In these experiments the soluble humin which is adsorbed by the lime used in neutralizing the hydrolysate when determining ammonia nitrogen, carried with it a larger amount of nitrogen than the insoluble humin. The sum of the insoluble plus the soluble humin nitrogen found amounts to 6.589 per cent, which constitutes no inconsiderable error, since at present it is impossible to determine the character of the nitrogen discarded in this form.

It may be noted by referring to table 1 that the amount of soluble humin nitrogen in the first four samples is considerably greater than in the succeeding four. Possibly this is due to a slight variation in the analytical procedure. In the case of samples C1 to C4, inclusive, it was necessary to add 75 to 90 cc. of calcium hydroxide in order to neutralize the hydrochloric acid before distillation of ammonia. About 20 cc. in excess were then added. With the next four samples evaporation of the acid hydrolysate in vacuo was continued longer in order to drive off a greater proportion of the hydrochloric acid. In consequence, only 30 to 40 cc. of calcium hydroxide were necessary to effect neutralization, and in these cases only a small excess, about 10 cc., of calcium hydroxide was added. The hypothesis is put forward that the presence of a large excess of calcium hydroxide during the distillation of ammonia may result in the adsorption of some amino acid nitrogen which is incompletely removed in the subsequent washing of the sticky mass.

When it is recalled that the proteins of cottonseed meal form approximately 43 per cent of the feedingstuff, the amount of nitrogen in the humin resulting from the hydrolysis of these proteins, as determined in these experiments, is not excessive when compared to the amounts obtained in the hydrolysis of

pure proteins by Van Slyke (8), some of whose results are shown in the accompanying table.

The amount of nitrogen recovered as ammonia was quite constant in all the samples. Little can be said in regard to the significance of this fraction, aside from the fact that the proportion of the total nitrogen of cottonseed meal which appears as ammonia is quite in harmony with that of other feedingstuffs.

A particularly characteristic feature of the amino acid content of cottonseed meal is the remarkably high content of arginine. This is much higher than that found in any other feeding stuff so far examined, with the exception of peanuts, although it is not so high as that found in some other vegetable proteins. Van Slyke (8) found 27.05 per cent arginine nitrogen in edestin

TABLE 4

Amounts of humin nitrogen in pure proteins expressed in percentage of the total nitrogen of the protein

PROTEIN AND DESCRIPTION	HUMIN NITROGEN
	per cent
Gliadin from wheat	0.86
Edestin	1.83
Fibrin (Merck's)	3.43
Oxyhemoglobin ("pure, crystalized")	3.60
Dog's hair	7.35

while Nollau reported that hemp seed, peanuts, black walnuts, and hickory nuts have an arginine nitrogen content of more than 20 per cent.

In the Van Slyke procedure the only amino acids determined by direct analysis are arginine and cystine. Just how much importance may be attached to the results obtained for the latter is questionable, even though the values found in the different samples do not vary widely. These values, however, probably fall short of the true value, due to losses in the determination of cystine. Van Slyke (8) has shown that boiling cystine for sixteen hours with hydrochloric acid resulted in the conversion of one-half of its nitrogen into forms not precipitable by phosphotungstic acid. Since in the analytical procedure described above, hydrolysis of the proteins was carried out by

boiling them with 20 per cent hydrochloric acid for fifteen hours, it is probable that much of the cystine was destroyed during that reaction. If it is assumed that the correct value for cystine should be double that actually obtained, then the total nitrogen of the bases would amount to 31.75 per cent of the total nitrogen of the feedingstuff.

The values given for histidine and lysine are somewhat variable among the different samples. These variations are likely due in large measure to the indirect method used in their determination, since slight errors in any or all of the three direct determinations of arginine nitrogen, cystine nitrogen and the total nitrogen of the bases are doubtless all reflected at these points.

The content of mono-amino acid nitrogen of cottonseed meal is considerably less than that found in other feedingstuffs, possibly due to the greater proportion of the total nitrogen which is formed by the basic amino acids. One of the interesting features of the results of the Van Slyke analysis of the proteins of cottonseed meal is brought out in the summation of the ammonia nitrogen, the nitrogen of the bases, mono-amino acid nitrogen, and non-amino acid nitrogen, the four groups which represent the total content of strictly amino acid nitrogen as determined by this method. The sum of these is 83.132 per cent. While this sum is not so great as that in the case of some other feedingstuffs or of animal proteins, as determined by previous investigators employing the Van Slyke method of analysis, it is a much larger amount than it was possible to secure in most cases from comparable sources by the methods of isolation and purification employed by the earlier investigators. Thus the tabulations of Lusk (22), combining the results of Osborne and associates in this field, show the maximum amino acid content of zein of maize, to be 88.87 per cent and that of gliadin of wheat as 85.68 per cent, but in the majority of cases the sum of the nitrogen content of the amino acids actually isolated from vegetable proteins ranges from 50 to 65 per cent of the total nitrogen of the protein.

Uncharacterized nitrogen lost in analysis. In the various steps of the analytical procedure small amounts of nitrogen of unknown character are included in residues and solutions which are discarded. In general, these have been disregarded by workers in other laboratories, especially those losses occurring at points indicated in table 2 by the last four of the subheadings included under the heading "Uncharacterized nitrogen lost in analysis," but in this laboratory the nitrogen discarded at each of these steps has been determined. Under the above mentioned headings, it is shown that, on the average, only 0.492 per cent of the total nitrogen remains in the residues insoluble in strong alkali, or in other words 99.508 per cent of the total nitrogen of the feedingstuff is extracted as a result of the method employed, and that in individual cases as much as 99.78 per cent of the total nitrogen present was removed. As previous workers failed to isolate the proteins from the feedingstuff before hydrolysis, it is not established that part of the insoluble residue discarded in their methods did not include some nitrogen in the form of non-hydrolyzed protein although this does not seem highly probable. It is believed, however, that the nearly complete extraction of the proteins before hydrolysis lends to the accuracy of the method by facilitating hydrolysis and in reducing the amount of humin.

The largest item of loss occurs in the residue which remains after dissolving the precipitate of the bases in the amyl alcohol-ether mixture. This, presumably, is soluble humin which has not been adsorbed by the lime in the determination of ammonia, and fouls the solution at this point. This difficulty was also encountered by Menaul (23), who employed a preliminary precipitation with phosphotungstic acid in boiling solution for the separation of the humin and ammonia before the precipitation of the bases. In the present investigation, very little of the soluble humin appeared when the bases were precipitated, in most cases the precipitates being free from black particles. Washing with alternate portions of amyl alcohol-ether and water and then taking up the residue and washing thoroughly with water seemed to have little effect in reducing this source

of loss. A considerable portion of the nitrogen lost is soluble in the amyl alcohol-ether mixture, while smaller losses occur in the residues resulting from concentration of the solutions of the bases and filtered from the bases. Presumably, the second, third and fourth items of loss include some nitrogen which should be credited to the bases, but the character of this nitrogen was not determined. If these losses can be reduced, the total nitrogen of the bases of cottonseed meal may be found to be somewhat greater than the amount here reported.

Total nitrogen accounted for. Summation of the nitrogen found in the various fractions of the protein molecule together with that in the unavoidable losses in the procedure gives totals which average 98.75 per cent. While the use of the Van Slyke method of analysis has enabled others to account for as great a proportion of the nitrogen of feedingstuffs, it is doubtful, for reasons pointed out below, if their results give as accurate a picture of the distribution of nitrogen in feedingstuffs as is obtained by the procedure employed in the present investigation.

Physiological significance of the basic amino acids. Our knowledge of the physiological rôle of arginine and histidine has been enhanced by the studies of Ackroyd and Hopkins (24). Employing rations in which the nitrogen was provided in the form of hydrolyzed casein from which these two amino acids had been removed by precipitation according to the method of Kossel and Kutcher, it was found that rats receiving these rations declined rapidly in weight, but that when either amino acid was returned to the ration, loss in weight was prevented and some growth ensued. The investigators suggest that possibly either of these amino acids may be converted into the other by the animal body. It was further observed that when arginine and histidine are removed from the ration, the excretion of allantoin, which is the main end product of purine metabolism in the rat, was lowered. Subsequent experiments proved that the falling off of allantoin excretion was not due to lowered metabolism. From these observations and from the fact that the arginine, histidine and guanine molecules have similar structural

relationships, it was concluded that possibly one of the functions of arginine and histidine is to furnish the raw material for the purine metabolism of the animal organism.

The above conclusion regarding the importance of arginine in purine metabolism is given added weight by the findings of Myer and Fine (25) regarding the creatine content of muscle. Differences of as much as 2.5 per cent in the creatine content of muscle were noted as a result of feeding rations high and low in arginine.

That cystine plays an important part in nutrition has been brought out by several investigators, among them Osborne and Mendel (26). The latter obtained adequate growth by the addition of cystine to rations containing 9 per cent of casein, on which growth had been limited. Geiling (27), working in this laboratory, concluded that cystine seems to be necessary for the maintenance of adult mice. The importance of cystine to the animal organism is admirably set forth by Matthews (28).

In the intermediary metabolism of the body, that is, the metabolism of the tissue, sulphur probably plays a very important rôle. This is shown not only by the fact that it is absolutely necessary for the continued existence of the body, as necessary as nitrogen or any of the other elements, but also by the fact that it is one of the most labile elements of the protein molecule. No other element is split off from the proteins with greater ease than this. It is, indeed, the labile element *par excellence.* Moreover, cysteine, which is one of the amino acids, readily oxidizes itself. It is a reducing body. It oxidizes spontaneously and there are many points in its oxidation which strongly resemble the process of respiration. Thus the most favorable concentration of hydrogen ions for the oxidation of cysteine is the same as that in protoplasm; both cysteine and protoplasm are poisoned by many of the same substances, such as the nitriles, the cyanides, acids, and the heavy metals; their oxidations are catalyzed or hastened in the same manner by iron, arsenic and some other agents. For these reasons it has been suggested by Hefter and the author that there is more than a superficial connection between the oxidation of cysteine and the respiration of the cell.

The necessity of lysine for growth has been conclusively demonstrated by Osborne and Mendel (29). When gliadin of wheat, which contains only a minute amount of lysine, formed the sole source of protein in the rations of rats, the live weight of the animals was maintained over long periods, but normal growth could not be secured. When lysine was added to the rations, normal growth occurred. In other investigations (30), in which zein of maize was used as the source of the protein, it was found that a rat could be maintained at an almost constant weight of 50 grams for a period of one hundred and eighty-two days when tryptophane was added to the extent of 3 per cent of the zein. The further addition of lysine induced normal growth. Further study (31) of the necessity of lysine in the ration convinced these investigators that about 2 per cent of the protein of the ration must consist of lysine in order to promote normal growth in the rat. Osborne and Mendel (32) also demonstrated the necessity of lysine for the growth of chickens.

In view of the essential rôle which the basic amino acids play in nutrition as brought out above, it is reasonable to assume from a survey of the analytical results of cottonseed meal secured in this investigation that the proteins of this feedingstuff have a high nutritive value. The combined arginine and histidine content of cottonseed meal is greater than that of any other feedingstuff so far analyzed with the exception of the peanut. This feature alone is of great importance in view of the fact that arginine and histidine seem to be interchangeable in nutrition. While the lysine content cannot be said to be exceptional in any particular it seems apparent from the above discussion, that the combined proteins of cottonseed meal contain sufficient amounts of both cystine and lysine to render them adequate for nutrition.

Comparison with previous analyses of cottonseed meal. As shown in the introduction, there are but few determinations of the chemical composition of the proteins of cottonseed meal. The earliest studies were made upon one of the isolated proteins, the globulin or "edestin" of cottonseed, the results of which can not well be compared to analyses of the combined

proteins, since, as previously mentioned, the globulin contains but 42.3 per cent of the total nitrogen of cottonseed meal. In the accompanying table 5, the values secured by two previous investigators who made analyses of the combined proteins of cottonseed meal are brought together for comparison with those obtained in this investigation.

It is evident from the results presented that there is a general agreement between the three sets of values, but that there are considerable differences in several important particulars. As pointed out in the introduction, Nollau (10) calculated his results upon the total nitrogen content of the hydrolyzed solution after filtering off the solid residue insoluble in hydrochloric

TABLE 5

Distribution of nitrogen in cottonseed meal as determined by different investigators

(Results expressed in percentage of the total nitrogen of the feeding stuff)

INVESTIGATOR	HUMIN N	AMMONIA N	ARGININE N	CYSTINE N	HISTIDINE N	LYSINE N	AMINO N IN FILTRATE FROM BASES	NON-AMINO N IN FILTRATE FROM BASES	TOTAL N ACCOUNTED FOR
Nollau	6.27	14 06	12.77	2 74	7.57	1.94	45.02	7.49	97.48
Grindley	7.78	10.45	19 52	0.65	5.47	4.78	42.82	5.43	96.90
Nevens	6.58	9.49	18.74	0.91	7 40	3.81	40.12	2.68	98.75[1]

[1] Includes 9.03 per cent N removed in preliminary extractions plus uncharacterized nitrogen lost in method of analysis.

acid. This means that all of his calculations are too high, since a part of the nitrogen of the sample was undoubtedly discarded in the solid residue. The value of 6.27 per cent humin nitrogen reported by Nollau must, therefore, represent the soluble humin nitrogen, which is nearly as large a value as that obtained by the writer for the sum of the insoluble humin nitrogen plus the soluble humin nitrogen. The amount of soluble humin nitrogen found by the writer was but 3.89 per cent. Compared to the total humin nitrogen found by Grindley, et al. (9), the amount of total humin nitrogen as determined by the writer was 1.19 per cent less. The reduction of the humin nitrogen has no doubt been an important contributing

factor in the present investigation in securing somewhat higher values of the basic amino aids. In view of the known effects of acid hydrolysis of the proteins in the presence of carbohydrates, as already pointed out, it is reasonable to assume that the smaller amount of nitrogen discarded in the form of humin in these experiments than in those of Grindley may be attributed to the more complete separation of the proteins from the carbohydrates before hydrolysis.

The method of analysis of the proteins after hydrolysis by hydrochloric acid, as employed by Grindley et al., was similar to that employed by the writer, the main point of difference between the complete procedures being in the omission by the former workers of the extractions previous to hydrolysis. At just what point the 6.106 per cent of nonprotein nitrogen removed by the writer in the preliminary extractions might appear were it not so removed, is not clear. However, the sum of the ammonia nitrogen, amino nitrogen and non-amino nitrogen in the filtrate from the bases, obtained by Grindley et al, is 6.414 per cent greater than the sum of the corresponding values obtained by the writer, so it is possible that these three forms of nitrogen as reported by the former comprise some nitrogen not derived from the proteins as such.

It is evident from the table that the nitrogen of the bases as found by Grindley and his coworkers are in much closer agreement with those obtained by the writer than those reported by Nollau. The latter's figures for arginine are obviously too low, while his cystine values are more than four times as great as those of Grindley et al. and three times as great as those of the writer. Accordingly, the lysine nitrogen values as calculated by Nollau are correspondingly too low. The values for the total nitrogen of the bases as found by the three investigators in the order given in the table are as follows: 25.02 per cent, 30.42 per cent and 30.84 per cent respectively, the last being nearly 0.5 per cent higher than previous determinations.

The total nitrogen accounted for in the three reports is likewise shown to be 97.86 per cent, 96.90 per cent and 98.75 per cent. The greater amount in the last case is evidently due in part

at least, to the inclusion of the determinations of the uncharacterized nitrogen lost at points were unavoidable losses occur in the method of analysis. These losses were not determined by the first two investigators.

Comparison of the distribution of nitrogen in cottonseed meal with that in other feedingstuffs. A comparison of the results of analysis of the proteins of cottonseed meal, as discussed above, with those obtained by Hamilton, Grindley and Nevens (33) for alfalfa hay, oats and corn is of value in studying the relative nutritive value of the proteins of these feedingstuffs, as well as the applicability of the general method of analysis to feedingstuffs which vary widely in composition. In the analysis of oats and corn an additional preliminary extraction, which involves the use of hot trichloracetic acid, is employed to remove the starch. This extraction is not necessary in the case of cottonseed meal and alfalfa hay on account of the absence of starch in the former, as stated by Withers and Fraps (34), and the relatively small amount of starch in the latter.

The first point of interest in contrasting these feedingstuffs, as may be noted by reference to table 6, is their content of nonprotein nitrogen. Oats contain more than twice as much nonprotein nitrogen as cottonseed meal, while alfalfa hay contains more than three times as much. Hart and Bentley (35) found that 23.5 per cent of the nitrogen of alfalfa hay is present in a water soluble form, while Grindley and Eckstein (16) found a value of 28.4 per cent for the same feedingstuff.

The amount of total humin is greatest in the case of alfalfa, a natural result, since the proteins are more difficultly extracted from those feedingstuffs containing large amounts of crude fiber. The amount of humin in the case of corn is very small indeed, considering the high percentage of carbohydrates in this cereal, and compares very favorably with the amounts of humin resulting from the hydrolysis of pure proteins as shown in table 3. Cottonseed meal occupies a medium position in respect to the proportion of humin nitrogen.

The most striking difference between these four feedingstuffs is in their basic amino nitrogen content. Cottonseed

TABLE 6

Comparison of the distribution of nitrogen in cottonseed meal with that in other feedingstuffs

(Results expressed in percentage of total nitrogen of the feedingstuff)

FEEDING-STUFF	NONPROTEIN NITROGEN				RESULTS OF THE VAN SLYKE ANALYSIS										NITROGEN LOST IN METHOD OF ANALYSIS							TOTAL
	Soluble in absolute ether	Soluble in absolute alcohol	In filtrate from colloidal iron	Total nonprotein nitrogen	Insoluble humin nitrogen	Soluble humin nitrogen	Ammonia nitrogen	Arginine nitrogen	Cystine nitrogen	Histidine nitrogen	Lysine nitrogen	Amino acid N in filtrate from bases	Non-amino acid N in filtrate from bases	Total nonprotein + results of Van Slyke analysis	N in residue after treatment with strong NaOH	In alcohol precipitate of hot 2 per cent CCl_3COOH extract	Unadsorbed humin (filtered from solution during decomposition of bases)	Soluble in amyl alcohol-ether mixture	In residue filtered from solution of bases	In residue filtered from solution of filtrate from bases	Total nitrogen lost	Total nitrogen accounted for
Alfalfa hay..	0.550	1.848	16.692	19.090	3 690	4.481	7.364	7 996	0.991	3 931	4.434	38 032	2.511	92.520	2.519		1 161	0.611		0.441	4.732	97.252
Oats. ...	0.569	1.225	11.129	12.926	3 013	2.516	11.422	11.647	0 944	5.796	2.841	42.137	3 860	97.100	0.132	0.127	0.664	0.746	0.209	0.025	1.903	99.004
Corn	0.326	1.368	8.135	9.829	1.235	2.303	11.936	8.725	1.072	4 832	2 200	46.704	7.216	96.052	0.136	0.276	2.698	0.481	0.191	0.065	3 847	99.899
Cotton-seed meal..	0.125	0.545	5.436	6.106	2 699	3.890	9.485	18.736	0.906	7.397	3.807	40.124	2.677	95.827	0.492		1.252	0.875	0.228	0.076	2.923	98.750

meal, as already indicated, is exceptionally high in arginine nitrogen, but it is also much higher in its total basic nitrogen content than the other three feedingstuffs, the values for the four feedingstuffs being: alfalfa hay, 17.412 per cent; oats, 21.228 per cent; corn, 17.529 per cent; and cottonseed meal, 30.846 per cent. The sum of the arginine nitrogen and histidine nitrogen is more than twice as great in the case of cottonseed meal as in the case of alfalfa hay and nearly twice as great as that of corn. From the considerations presented above regarding the biological significance of the basic amino acids, it would be logical to assume that these wide differences in the chemical composition of the proteins of different feedingstuffs indicate similar differences in their nutritive value, though probably not in corresponding degree. This point is mentioned in another paper in connection with the discussion of the results of the feeding experiment conducted for the purpose of studying the nutritive value of the proteins of cottonseed meal.

Alfalfa hay contains the smallest proportion of mono-amino acid nitrogen, possibly owing to its high content of nonprotein nitrogen while corn is exceptionally high in its content of both mono-amino and non-amino acid nitrogen.

The largest amount of nitrogen lost in the method of analysis occurs in the case of alfalfa, which is accounted for largely in the nitrogen remaining in the residues after the preliminary extractions have been completed. The next largest amount is in the case of corn, where the bulk of the loss is due to unadsorbed humin. The nitrogen is extracted very completely from both oats and corn. Cottonseed meal occupies a medium position with respect to the nitrogen lost in the analytical procedure.

The total nitrogen accounted for in the case of the various feedingstuffs is a point worthy of special note. The total is least in the case of alfalfa and greatest with corn. Here again cottonseed meal occupies a medium position. In this rather long method of analysis, which involves many extractions, concentrations, precipitations, filtrations and transfers, and which at some stages renders the proteins subject to putrefaction unless care

is taken, only 0.101 per cent of the total nitrogen originally present in the sample of corn was not accounted for, a very remarkable result indeed.

An examination of the results of individual analyses of the four samples of alfalfa hay and six samples each of oats and corn which were averaged to obtain the values shown in table 6, brings out the fact that the analytical results in the case of each of these feedingstuffs show, on the whole, less variability than the values for the eight samples of cottonseed meal shown in table 2. At least two factors operated to effect the difference. The analyses of the first three feedingstuffs mentioned were conducted by persons experienced in the manipulation and execution of the Van Slyke analysis and the analyses used for the averages were selected from a number of analyses. The analyses of cottonseed meal were made by the writer who had had no previous experience in the conduct of the Van Slyke method, and the analyses presented in table 1 are the entire results of the work. These considerations are strong evidence that the method of analysis here described is of general application to feedingstuffs and may readily be carried out.

Summary of the discussion of the results of the chemical analysis of the proteins. The accuracy of the determination of the amino acid content of the proteins of cottonseed meal has been increased over that of previous methods by the removal of the nonprotein nitrogen before proceeding with the hydrolysis of the proteins.

The accuracy of the determination has been still further increased by the reduction of the humin substances formed as a result of the hydrolysis of the proteins.

The amount of arginine nitrogen is much higher than that in most other feedingstuffs. The sum of the four basic amino acids is about 0.5 per cent higher than values previously found for cottonseed meal.

The method of extraction employed was found to result in the removal of 99.5 per cent of the total nitrogen present in the feedingstuff.

The sum of the ammonia nitrogen and amino acid nitrogen fractions is 83.132 per cent of the total nitrogen, an amount comparable to the sum of the same fractions previously obtained from pure vegetable proteins.

Of the total nitrogen originally present in the sample of cottonseed meal, 98.75 per cent was accounted for by summation of the fractions obtained at different stages in the method of analysis, a proportion greater than any previously reported for the same feedingstuff.

The complete method of analysis outlined in this paper is believed to be of general application to feedingstuffs and may readily be executed with successful results.

The writer is greatly indebted to Dr. H. S. Grindley for many courtesies extended during the course of this investigation in addition to his constructive criticism and general supervision of the work. His thanks are also due Mr. T. S. Hamilton for advice regarding certain analytical procedures.

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METHODS OF CALCULATING ICE CREAM MIXES[1]

H. H. SOMMER

Department of Dairying, University of Wisconsin, Madison, Wisconsin

To calculate an ice cream mix so as to obtain a definite fat and solids content, we must know the composition of the ingredients. The table on page 402 gives the approximate composition of the materials commonly used in ice cream mixes.

In order to do accurate work, the mix should be made up on the basis of weight and not by volume. However, ice cream is sold by the gallon, and as a result we think of the mix in terms of gallons. In order to convert gallons into weight we must know the weight of a gallon of mix.

The weight of a gallon of mix varies according to its composition. The easiest way of getting the weight is, of course, by actual weighing. However, if the composition of the mix is known, we can calculate the theoretical weight per gallon.

In this calculation we assume that butterfat has a specific gravity of 0.93; the serum solids, 1.58; the sugar and gelatine 1.58; and the water 1.00. If we have a mix containing 12 per cent fat and 36 per cent total solids, then in 100 grams of this mix we have:

12 grams fat occupying $\frac{12}{0.93}$ or 12.903 cc.

24 grams other solids occupying $\frac{24}{1.58}$ or 15.190 cc.

64 grams water occupying $\frac{64}{1.00}$ or 64.000 cc.

The 100 grams of mix occupying 92.093 cc.

Therefore the specific gravity of the mix will be $\frac{100}{92.093}$ or 1.0857. A gallon of water weighs 8.34 pounds, therefore a gallon of this mix will weigh 8.34×1.0857 or 9.05 pounds.

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

Gathering all these calculations into one general expression we get:

$$\frac{100}{\dfrac{\text{per cent fat}}{0.93}+\dfrac{\text{per cent s.n.f.*}}{1.58}+\dfrac{\text{per cent water}}{1.00}}\times 8.34 = \text{weight per gallon of mix.}$$

* Sugar, gelatine and milk solids not fat.

	FAT	MILK SOLIDS NOT FAT	TOTAL SOLIDS
	per cent	*per cent*	
Skim milk	0	8.9*	8.9
Milk	Test	8.5 per cent or (100 − per cent fat) × 0.089†	8.5 per cent + per cent fat or (0.911 × per cent fat) + 8.9‡
Cream	Test	(100 − per cent fat) × 0.089†	(0.911 × per cent fat) + 8.9
Evaporated milk	7.8	17.7	25.5
Condensed milk	8.0	20.0	28 − 40 wer cent sugar
Condensed skim milk	0	28 − 32 (varies)	28 − 32 (varies)
Skim milk powder	1.0	94.0	95.0
Butter	Test	1.0	Per cent fat + 1.0
Sugar	0	0	95.0
Gelatine	0	0	100.0
Flavoring extracts	0	0	0

* Usually we do not have an analysis of the skim milk so that in the calculations an assumption has to be made. It is assumed here that the solids content is 8.9 per cent for skim milk from mixed milk.

† If we assume a certain figure for the solids not fat in the skim milk then we can calculate the solids not fat in whole milk or cream as follows: Per cent s.n.f. = (100 − per cent fat) × 0.089.

For example if we have 100 pounds of 25 per cent cream we have 25 pounds of butter fat and 75 pounds of skim milk. If the skim milk contains 8.9 per cent s.n.f then we will have 75 × 0.089 or 6.675 pounds of s.n.f. in the 100 pounds of cream or 6.675 per cent.

‡ The total solids of milk or cream will be the fat plus s.n.f. We concluded that the s.n.f. can be calculated as follows:

Per cent s.n.f. = (100 − per cent fat) × 0.089;

therefore the total solids must be:

Per cent fat + (100 − per cent fat) × 0.089.

By simplifying the expression we get:

Total solids = (0.911 × per cent fat) + 8.9.

CALCULATING A SIMPLE MIX

By a simple mix we mean one in which no condensed milk product is used, but where the total solids content of the mix is

incidental to the amount of fat furnished by the milk and cream, and the amount of sugar used.

PROCEDURE AND SAMPLE CALCULATION

Object. To prepare 100 pounds mix to contain 14 per cent fat, 14 per cent sugar, 0.5 per cent gelatine, and 0.5 per cent vanilla.

Procedure

Step I. Calculate weight of fat necessary.

$$100 \times 14 \text{ per cent} = 14 \text{ pounds fat}$$

Step II. Calculate weight of sugar, gelatine and vanilla.

		pounds.
100 × 14 per cent sugar	=	14.0
100 × 0.5 per cent gelatine	=	0.5
100 × 0.5 per cent vanilla	=	0.5
Total	=	15.0

Step III. Calculate weight of cream and milk necessary, total weight of mix minus weight sugar gelatine and vanilla.

$$100 - 15 = 85 \text{ pounds of cream and milk}$$

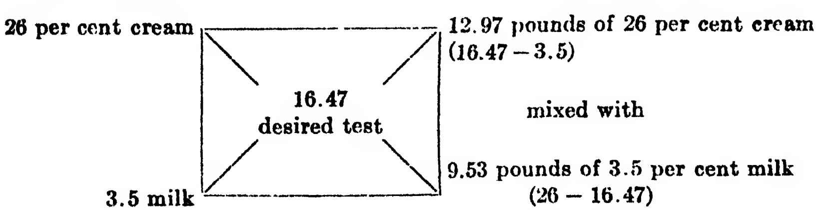
Step IV. Calculate the necessary fat test of the milk and cream mixture.

$$\frac{\text{Pounds of fat required}}{\text{Weight of cream and milk}} \times 100 = \text{fat test}$$

$$\frac{14.00}{85.0} \times 100 = 16.47 \text{ per cent}$$

Step V. Calculate the amount of cream and milk to mix to produce the required weight of mixture at the required fat test. This is best done by the Pearson square method.

Let us assume we have a 26 per cent cream and 3.5 milk.



produces 22.5 pounds mixture testing 16.47 per cent

However, we do not want 22.5 pounds, but 85 pounds. Therefore we must take $\frac{85}{22.5}$ or 3.778 times as much milk and cream.

$$12.97 \text{ pounds cream} \times 3.778 = 49.0 \text{ pounds cream}$$
$$9.53 \text{ pounds milk} \times 3.778 = 36.0 \text{ pounds milk}$$

Step VI. Tabulate the amounts of ingredients and calculate how much fat and solids each contributes, making use of the table of composition given above.

	FAT	SOLIDS
	pounds	*pounds*
49.0 pounds cream	12.74	15.93*
36.0 pounds milk	1.26	4.32†
14.0 pounds sugar	0	13.30‡
0.5 pounds gelatine	0	0.50
0.5 pounds (8 ounces) vanilla	0	0
	14.00 or 14.0 per cent	34.05 or 34.05 per cent

* Per cent solids in cream = (0.911 × per cent fat) plus 8.9.
† Per cent solids in milk = 3.5 per cent fat plus 8.5 per cent s.n.f.
‡ Per cent solids in sugar = 95 per cent.

After the recipe has been calculated, the daily calculations start with step IV. As the cream and milk tests vary, they will have to be mixed in different proportions to get the required amount of mixture at the desired test (in our illustration 85 pounds of milk and cream mixture testing 16.47 per cent fat).

COMPLEX ICE CREAM MIXES

In a simple ice cream mix we are satisfied with the solids content that may be incidental to the fat and sugar content. With the use of condensed milk products, the calculations become more complex. In calculating such a mix we not only have a definite aim as to the fat content, but also as to the solids content. We must mix the milk, cream and condensed milk product in such proportion as to obtain both the required fat and solids content simultaneously. This is further complicated if we use a sweetened condensed milk.

In attempting to proportion the amounts of three ingredients to obtain a given weight of mixture of a certain fat and solids content, the method that suggests itself at once is to make use of algebra and solve this problem by the use of simultaneous equations. For example if we wish to make 100 pounds of a mixture of cream, milk, and evaporated milk, to contain 16 per cent fat and 27 per cent solids, and if the milk contains 3 per cent fat, 12 per cent total solids; the cream 28 per cent fat, 34.5 per cent total solids; and the evaporated milk 8 per cent fat, 26 per cent total solids, letting x represent the weight of milk, y the weight of cream, z the weight of evaporated milk, we can construct the following equations.

$$x + y + z = 100$$

$$\frac{3x + 28y + 8z}{100} = 16$$

$$\frac{12x + 34.5y + 26z}{100} = 27$$

Having these three simultaneous equations we can solve for the three unknowns.

This kind of a calculation will obtain the desired results but is too complex to be of any practical use.

In the absence of any definite practical methods for calculating complex mixes exactly, the practice has been to resort more or less to guesswork, estimating the amount of condensed milk product to use and furnishing the remainder of the fat by milk and cream. If the total solids content figured out from this was too far from the desired amount, the mix would have to be recalculated and this repeated until after numerous trials the desired composition was approximated.

The following method has been devised to relieve this situation. By means of this method guesswork is eliminated and an exact calculation given in its place.

DERIVATION OF THE METHOD

In any mix we can easily calculate the fat and total solids contents necessary in the mixture of milk, cream and condensed

milk product, so that when the sugar, gelatine and vanilla are added it will be diluted down to the exact fat and solids content desired in the finished mix. The problem in a complex mix is to mix the cream, milk, and condensed milk product in the proper proportions.

If we mix cream and evaporated milk in such proportions that the mixture has a given fat test, the total solids content of the mixture will depend upon the richness of the cream used. The following examples will illustrate this.

If we mix 40 per cent cream and evaporated milk (7.8 per cent fat, 25.5 per cent total solids) in such proportions that we get a mixture testing 15 per cent fat, the mixture will contain 29.59 per cent solids.

If we use 20 per cent cream instead of 40 per cent cream the mixture containing 15 per cent fat will contain 25.86 per cent solids.

Mixture 1

	FAT	SOLIDS
	pounds	*pounds*
7.2 pounds 40 per cent cream..........	2.88	3.164
25.0 pounds evaporated milk............	1.95	6.375
32.2 pounds mixture containing..........	4.83 or 15.0 per cent	9.539 or 29.5 per cent

Mixture 2

	FAT	SOLIDS
	pounds	*pounds*
7.2 pounds 20 per cent cream....... .	1.44	1.880
5.0 pounds evaporated milk.......... ..	0.39	1.275
12.2 pounds mixture containing...........	1.83 or 15.0 per cent	3.155 or 25.86 per cent

From the above figures it is seen that both mixtures have the same fat content; but where the richer cream was used the solids content is higher. It follows that the secret of getting the desired fat and solids contents simultaneously lies in deter-

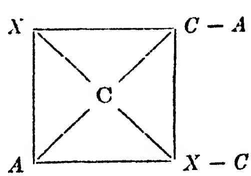
mining the necessary fat content of the cream, which, when thinned down (with regard to the fat) by the condensed milk product will give you both the desired fat and a solids contents.

Since we wish to mix cream and a condensed milk product in such proportions to obtain both a definite fat and solids content, we can momentarily look at the problem from two different viewpoints: (1) we can determine the proportion of cream to condensed milk product necessary to obtain the desired fat content; (2) we can determine the proportion of cream to condensed milk product to obtain the desired solids content. However, if these two, the fat and solids contents, are to be obtained simultaneously in the mixture it is necessary that these two proportions be equal. This is possible only for one particular fat content in the cream. By equating those two proportions and having all the values known except the test of the cream, we can calculate the test of the cream necessary to obtain the fat and solids contents simultaneously.

To express this in the form of an equation let the following letters represent the composition of the products used:

A = fat content of condensed milk product.
B = solids content of condensed milk product.
C = desired fat content in the mixture.
D = desired solids content in the mixture
X = fat test of the cream.

By means of Pearson's Square Method we can calculate the proportion of cream to condensed milk product necessary to obtain the desired fat content in the mixture.



From this it is seen that the proportion in which the cream testing X must be mixed with the condensed milk product testing A per cent fat to obtain fat content C is $\frac{C-A}{X-C}$.

Similarly we can calculate the proportion in which these two ingredients must be mixed to obtain the desired total solids content.

$$\begin{array}{lcl}
(0.911X + 8.9) & & D - B \\
\text{(Solids content of cream)} & D & \\
B & & 0.911X + 8.9 - D
\end{array}$$

(Solids content of condensed milk product)

The proportion in which the cream testing X per cent fat must be mixed with the condensed milk product testing B per cent solids to obtain the solids content D is $\frac{D - B}{0.911\,X + 8.9 - D}$.

On equating these two proportions we have:

$$\frac{C - A}{X - C} = \frac{D - B}{0.911X + 8.9 - D}$$

On simplifying this expression by multiplying and transposing the following equation results:

$$X = \frac{BC + 8.9\,A - 8.9\,C - AD}{0.911\,C + B - 0.911\,A - D}$$

By means of this equation the necessary cream test can be calculated; so that when this cream is mixed with the condensed milk product in the proper proportion to obtain the desired fat test, the desired solids content is obtained simultaneously.

PROCEDURE AND SAMPLE CALCULATION

Object. To prepare 100 pounds of mix of the following composition: 12.2 per cent fat, 13.0 per cent sugar, 37.0 per cent total solids, 0.5 per cent gelatine dissolved in 6 times its weight of water, 0.5 per cent vanilla.

The following dairy products are to be used: 3.5 per cent milk, 32.0 per cent cream, evaporated milk 8.0 per cent fat, 26 per cent solids.

Procedure

Step I. Calculate the weight of fat necessary.

$$100 \times 12.2 \text{ per cent} = 12.2 \text{ pounds fat}$$

Step II. Calculate the weight of sugar, stabilizer, and vanilla necessary.

100 × 13.0 per cent sugar	=	13 pounds sugar
100 × 0.5 per cent gelatine	=	0.5 pounds gelatine
100 × 3.0 per cent water to dissolve gelatine	=	3.0 pounds water
100 × 0.5 per cent vanilla	=	0.5 pounds vanilla
Total	=	17.0 pounds.

Step III. Calculate the actual weight of solids in the above:

13 pounds sugar × 95 per cent	=	12.35
0.5 pounds gelatine equals 100	=	0.5
0.5 pounds vanilla × 0.00	=	0.0 pounds.
Total	=	12.85 pounds solids

Step IV. Calculate the total weight of solids necessary

100 × 37 per cent = 37.0 pounds solids

Step V. Calculate the weight of solids to be furnished by the milk, cream and condensed milk product

37 − 12.85 = 24.15 pounds milk solids

Step VI. Calculate the weight of milk products.

100 − 17.0 = 83.0 pounds of milk, cream, etc.

Step VII. Calculate the fat test necessary so that the weight of milk products (Step VI) will furnish the weight of fat needed (Step I)

$$\frac{12.2}{83.0} \times 100 = 14.70 \text{ per cent fat.}$$

Step VIII. Calculate the solids test necessary so that the weight of milk products (Step VI) will furnish the weight of milk solids needed (Step V)

$$\frac{24.15}{83.0} \times 100 = 29.096$$

Step IX. Calculate the test of the cream necessary so that when the condensed milk product is added the desired fat and solids contents are obtained simultaneously. Use the formula derived above

$$X = \frac{BC + 8.9\,A - 8.9\,C - AD}{0.911\,C + B - 0.911\,A - D}$$

$A = 8.0$ (The fat in the evaporated milk)
$B = 26.0$ (The solids in the evaporated milk)

C = 14.70 (The desired fat test in the mixture)
D = 29.096 (The desired solids in the mixture)
X = the test of cream to be found
Substituting these values in the equation:

$$X = \frac{(26.0 \times 14.70) + (8.9 \times 8.0) - (8.9 \times 14.70) - (8 \times 29.096)}{(0.911 \times 14.7) + 26.0 - (0.911 \times 8.0) - 29.096}$$

$$X = \frac{382.2 + 71.2 - 130.83 - 232.768}{13.3917 + 26 - 7.288 - 29.096}$$

$$X = \frac{89.802}{30.077} = 29.857 \text{ per cent}$$

Step X. Calculate the amounts of this cream and condensed milk product to use.

29 857 — 6.7 pounds of cream

14 7 — plus

8 — 15 157 pounds of evaporated milk

produces 21 857 pounds of mixture testing 14 7 fat.

We want 83 pounds of mixture or $\frac{83}{21.857}$ or 3.797 times as much:

6.7 pounds cream × 3.797 = 25.44 pounds.

15.157 pounds evaporated milk × 3.797 = 57.56 pounds.

Step XI. Calculate the amount of cream and milk to mix to produce the thinner cream testing x per cent fat.

32.0 — 26.357 pounds cream

29.857 — plus

3 5 — 2 143 pounds milk

produces 28 500 pounds of cream 29.857 per cent fat.

We want 25.44 pounds of cream or $\frac{25.44}{28.50}$ or 0.9 times as much.

26.357 × = 23.511 pounds of cream.

2.143 × 0.9 = 1.929 pounds of milk.

Step XII. Tabulate the mix as calculated, figure the amount of fat and solids each ingredient contributes, and obtain the totals.

	FAT	SOLIDS
	pounds	*pounds*
23.511 pounds cream 32 per cent	7.5235	8.9464
1.929 pounds milk 3.5 per cent	0.0675	0.2332
57.56 pounds evaporated milk	4.6048	14.9656
13.00 pounds sugar	0	12.3500
0.50 pounds gelatine	0	0.5000
3.00 pounds water	0	0
0 50 pounds vanilla	0	0
100.00 pounds	12.1958	36.9952

Note: The daily calculations start with Step XI and are very simple. After a recipe has once been figured out and the necessary fat test of the cream (the value of x in the formula) determined, it is only necessary each day to figure out how much of the particular milk and cream on hand to mix to get the desired weight of cream testing x.

A new recipe has to be figured only when a condensed milk product of different composition is used.

CALCULATING A MIX IN WHICH A SWEETENED CONDENSED MILK PRODUCT IS USED

The calculation of an ice cream mix is further complicated if we use a sweetened milk product. We are then adding sugar from two different sources, and we cannot tell how much sugar to add in a dry form until we know how much sweetened condensed milk we are going to use, and vice versa.

In order not to complicate the calculation unnecessarily the moisture content of the dry sugar is ignored. However, by a slight change in the calculation this could easily be taken into consideration.

In the use of sweetened condensed milk in a mix the calculations can be simplified and made exact, if we assume in our calculations that we can for the time being remove the sugar from the condensed milk. If we had 100 pounds of condensed milk containing 8 per cent fat, 30 per cent milk solids, and 40

per cent sugar, we would have 60 pounds of condensed milk left if the 40 pounds of sugar were removed. The fat and solids content of these 60 pounds of *hypothetical condensed milk* would be $\frac{60}{8} \times 100$ or $13\frac{1}{3}$ per cent of fat, and $\frac{30}{60} \times 100$ or 50 per cent solids.

In our calculations we shall deal with the *hypothetical condensed milk*, and after the amount has been calculated figure how much sugar will be associated with it, and take that much less crystalline cane sugar.

PROCEDURE AND SAMPLE CALCULATION.

Object. To prepare 100 pounds of mix of the following composition: 12 per cent fat, 13 per cent sugar, 36 total solids, 0.5 per cent gelatine dissolved in 5 times its weight of water, 0.5 per cent vanilla.

The following dairy products are to be used: Cream 25 per cent. fat, milk 3.5 per cent fat, sweetened condensed milk containing 8 per cent fat, 30 per cent milk solids and 40 per cent sugar.

Step I. Calculate the weight of fat necessary:

100 × 12 per cent fat equals 12 pounds fat

Step II. Calculate the weight of sugar stabilizer and vanilla necessary:

100 × 13 per cent sugar	= 13	pounds sugar
100 × 3 per cent gelatine solution	= 3	pounds gelatine solution
100 × 0.5 per cent vanilla	= 0.5	pounds vanilla
Total	= 16.5	pounds

Step. III. Calculate the actual weight of solids in the above:

13.0 pounds sugar	= 13	pounds solids
3.0 pounds gelatine solution	= 0.5	pounds solids
0.5 pounds vanilla	= 0.0	pounds solids
Total	= 13.5	pounds solids

Step IV. Calculate the total weight of solids necessary:

100 x 36 per cent solids = 36 pounds solids

Step V. Calculate the weight of solids to be furnished by the milk cream and condensed milk product:

36 − 13.5 = 22.5 pounds solids

Step VI. Calculate the weight of milk products:

$$100 - 16.5 = 83.5 \text{ pounds}$$

Step VII. Calculate the fat test necessary so that the weight of milk products (Step VI) will furnish the weight of fat needed (Step I):

$$\frac{12}{83.5} \times 100 = 14.371 \text{ per cent fat}$$

Step VIII. Calculate the solids content necessary so that the weight of milk products (Step VI) will furnish the weight of solids needed (Step V):

$$\frac{22.5}{83.5} \times 100 = 26.946 \text{ per cent solids}$$

Step IX. Calculate the test of cream necessary so that when the condensed milk product is added the desired fat and solids contents are obtained simultaneously:

$$X = \frac{BC + 8.9\,A - 8.9\,C - AD}{0.911\,C + B - 0.911\,A - D}$$

A = $13\frac{1}{3}$ per cent (the fat in the hypothetical condensed milk)
B = 50 per cent (The solids in the hypothetical condensed milk)
C = 14.371 per cent (the desired fat in the mixture)
D = 26.946 per cent (the desired solids in the mixture)
X = the fat test of the cream

$$X = \frac{(50 \times 14.371) + (8.9 \times 13\frac{1}{3}) - (8.9 \times 14.371) - (13\frac{1}{3} \times 26.946)}{(0.911 \times 14.371) + 50 - (0.911 \times 13\frac{1}{3}) - 26.946}$$

$$X = \frac{718.550 + 118.666 - 127.902 - 359.280}{13.092 + 50 - 12.146 - 26.946}$$

$$X = \frac{350.034}{24.000} = 14.583$$

Step X. Calculate the amounts of this cream and condensed milk product to use:

14.583   1.038 pounds cream

           14.371

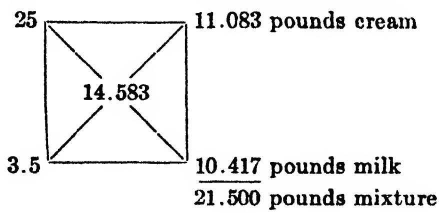
13.333   0.212 pounds hypothetical condensed milk
                         1.250 pounds mixture.

We need $\frac{83.5}{1.25}$ or 66.8 times as much:

$1.038 \times 66.8 = 69.34$ pounds cream

$0.202 \times 66.8 = 14.16$ pounds hypothetical condensed milk.

Step XI. Calculate the amount of cream and milk to mix to produce the thinner cream testing X per cent fat:



We need $\frac{69.34}{21.5}$ or 3.225 times as much:

$11.083 \times 3.225 = 35.75$ pounds cream

$10.417 \times 3.225 = 33.59$ pounds milk

Step XII. Tabulate the mix as calculated, figure the amount of sugar associated with the calculated amount of *hypothetical condensed milk*, the amount of dry sugar to use, and the amount of fat and solids in the entire finished mix. The figures thus far obtained are:

35.75 pounds cream 25 per cent
33.59 pounds milk 3.5 per cent
14.16 pounds hypothetical condensed milk
13.00 pounds sugar
3.00 pounds gelatine solution
0.50 pounds vanilla extract

To convert the weight of *hypothetical condensed milk* into the corresponding weight of actual condensed milk we have to calculate as follows:

$$\frac{\text{Weight of hypothetical condensed milk} \times 100}{100 - \text{sugar content of condensed milk}} = \text{weight of condensed milk}$$

$$\frac{14.16 \times 100}{100 - 40} = 23.6 \text{ pounds of condensed milk}$$

This weight of condensed milk contains 23.6×40 per cent or 9.44 pounds of cane sugar, therefore instead of 13.0 pounds we must use 13.0 − 9.44 or 3.56 pounds of cane sugar.

On tabulating the completed calculation we have:

	SUGAR	FAT	SOLIDS
	pounds	*pounds*	*pounds*
35.75 pounds cream 25 per cent	0	8.938	11.324
33.59 pounds milk 3.5 per cent	0	1.176	4.061
23.60 pounds condensed milk	9.44	1.888	16.520
3.56 pounds sugar	3.56	0	3.560
3.00 pounds gelatine solution	0	0	0.500
0.50 pounds vanilla extract	0	0	0
100.00 pounds	13 00	12.002	35.965

SUMMARY AND CONCLUSIONS

1. A table giving the approximate composition of materials commonly used in ice cream mixes is given.

2. It is recommended that mixes be calculated on the basis of a hundred pounds.

3. The method of calculating the theoretical weight of a gallon of ice cream mix is explained.

4. A method is derived and sample calculations are given for calculating complex ice cream mixes.

5. The method given is in itself not very short, but it is recommended as practical, because it is used only in calculating new recipes. The entire calculations do not have to be repeated every day.

DAIRY PRODUCTS INVESTIGATIONAL PROJECTS CARRIED ON BY THE AGRICULTURAL EXPERIMENT STATIONS IN 1919

ROY C. POTTS

Bureau of Markets, United States Department of Agriculture, Washington, D. C.

This list was compiled from a 225 page mimeographed booklet of Experiment Station Projects prepared in the office of Experiment Stations of the United States Department of Agriculture. Supplementing it is a statement of the dairy products activities undertaken by the Dairy Division of the Bureau of Animal Industry and the Dairy Marketing Division of the Bureau of Markets of the United States Department. This list of dairy activities of the State Agricultural Experiment Stations and the United States Department of Agriculture should be of interest to the members of the American Dairy Science Association, for it indicates, in general the various phases of the dairy products industry to which the dairy investigators of this country are giving particular attention. This list should be studied carefully, for it may suggest possible opportunities for coördination of work and coöperation among workers in obtaining better results, also a need of investigations of certain important phases which are entirely omitted or ignored at present.

This list is for the year 1919. Why could not this association compile a list of the 1920 projects also those proposed for 1921? Who shall undertake that task? The editor-in-chief, would appreciate your views on this proposition.

LIST OF STATE AGRICULTURAL EXPERIMENT STATION DAIRY PRODUCTS PROJECTS

Chemical studies of dairy products

1. Study of the properties of pure casein. N. Y. State.
2. Study of carbonic acid in milk. N. Y. State.

3. Study of the chemistry of butterfat and the effect of food in modifying its chemical and physical character. Mass.
4. Method for preliminary detection of abnormal milk. N. Y. State.
5. Method of determination of keeping quality of milk. N. Y. State.

Nutrition studies of dairy products

1. Role of dairy products in practical nutrition. Okla.
2. Food value of various milks for infants and invalids. Maryland.
3. Nutritive value of milk for children and animals. Vermont.
4. Minimum quantity of butterfat necessary to produce normal development in young growing animals. Ore.

Bacteriological studies of dairy products

1. Investigations in connection with raw and manufactured dairy products. Mich.
2. The influence of barn factors on the germ content of milk. Ill.
3. Species of bacteria found in dairy utensils. N. Y. Cornell.
4. The important factors in the production of sanitary milk and the means and methods on milk examination. N. Y. State.
5. Bacteriological examinations of certified milk. Calif.
6. A study of the true accuracy of bacterial counts as made from milk. N. Y. State.
7. The determination of the bacterial content of milk by a rapid method (little plate method). Wis.
8. The bacteria content of milk from milking to cooling. S. C.
9. Studies on cooling of milk in relation to its bacterial quality. N. Y. State.
10. The American high acid organisms found in milk. Iowa.
11. Acid production and the rate of growth of the lactic acid organism in the souring of milk. N. Y. State.
12. Studies on the bacterial flavors and odors of milk.
13. A study of the torula forms responsible for the yeasty fermentation in cream. Iowa.
14. The effect of preservatives on the bacteria in milk. Penn.
15. The use of available chlorin as a germicide in milk and milk products. Ark.
16. The bacteriology of butter. Okla.
17. A chemical and bacteriological study of the keeping qualities of butter. Ind.

18. A study of mold development on butter. Calif.
19. A study of the types or organisms present and multiplying in cottage cheese. Idaho.
20. Studies on the relation between the bacterial flora of good quality cheese and of good quality milk. N. Y. State.
21. Studies of the compounds in cheese and their changes under the influence of certain classes of bacteria. N. Y. State.
22. Chemical and bacteriological studies of ice cream. Ind.

Studies of butter and butter making

1. Influence of acidity of cream on flavor and keeping qualities of resulting butter. Iowa.
2. The neutralizing of the acidity of cream for buttermaking. Ore.
3. The effect of neutralization on the quantity of butter. N. Y. Cornell.
4. The chemistry of churning. Miss.
5. The cause of difficult churning. Wash.
6. Factors influencing grade of butter. Okla
7. A study of California butter at the Davis and San Francisco Markets. Calif.
8. Comparison of creamery and market weights of butter. Wis.
9. Study of dairy plant records. N. Y. Cornell.
10. Creamery building and improvement. N. C.
11. Keeping qualities of butter. Mich.
12. Keeping qualities of butter in storage as affected by methods in making.
13. A chemical and bacteriological study of the keeping qualities of butter. Ind.
14. A study of mold development on butter. Calif.
15. Scoring contests of commercial creamery butter. Idaho.
16. The bacteriology of butter. Okla.

Studies of cheese and cheese making

1. Mountain cheese work. N. C.
2. Making cheese. N. C.
3. Cheese investigations. Wis.
4. A study of the manufacture of cheese and whey. Calif.
5. Studies of the compounds in cheese and their changes under the influence of certain classes of bacteria. N. Y. State.
6. Factors concerned in the coagulation of milk by heat. Wis.

7. Yield of cheese from milk high and low in fat. Wis.
8. Pasteurization of milk for cheese making. N. Y. Cornell.
9. The effect of clarifying milk for making Cheddar cheese. N. Y. Cornell.
10. Studies in cheese making. Effect of temperature of cooking on texture of cheese; effect of amount of rennet or pepsin on rapidity of curing cheese; the possibility of curing cheese in Oklahoma factories; controlling factors in proper handling and marketing of cheese in Oklahoma. Okla.
11. The effect of separating temperatures on the loss of fat in separated whey. Oregon.
12. Studies on the relation between the bacterial flora of good quality cheese and of good quality milk. N. Y. State.
13. A study of the types of organisms present and multiplying in cottage cheese. Idaho.
14. A study of the control of mold development in cheese-curing rooms. Calif.
15. The use of *Bacillus bulgaricus* starter for controlling gassy milk in the manufacture of Cheddar cheese. Calif.
16. The effect of washing curd on the yield and quality of Cheddar cheese. N. Y. Cornell.
17. The use of pepsin as a substitute for rennet in the manufacture of California (granular) and Cheddar cheese. Calif.
18. Studies in the manufacture of Swiss cheese in vats. Ore.
19. The manufacture of Camembert, Swiss, and albumin cheeses. N. Y. Cornell.
20. Cheese making.—(Cottage, Neufchatel, whey, Romano, Etc.) A study of the practice of cheese making with special reference to the manufacture of foreign cheeses. Vt.
21. Relation of moisture and acidity to keeping quality of Neufchatel and cream cheeses. N. Y. Cornell.
22. The manufacture of cottage cheese from a mixture of skim milk using *Bacillus bulgaricus* starter for curdling the milk. Calif.
23. The manufacture of a skim milk cheese that will keep. S. Dak.

Cream production studies.

1. A study of some factors affecting the texture of the cream. Calif.
2. Losses in farm skimming of cream. N. C.
3. Factors affecting the efficiency of hand separators and causes of variation in cream tests. Nebr.

4. A study of the efficiency of the various cream cooling tanks. Nebr.
5. Cream routes. N. C.
6. An investigation regarding the whipping of cream. Wash.
7. A study of the Torula forms responsible for the yeasty fermentation in cream. Iowa.

Ice cream studies

1. Ice cream investigations. Kan.
2. Studies in ice cream making. Okla.
3. Commercial ice cream making. Okla.
4. Testing ice cream for butter fat. A comparison of various acids as to time required, ease of manipulation, character and accuracy of test; comparison of different ingredients upon character of test, such as sugar, gelatin, gum tragacanth, and ice cream powder, fruits, eggs, and color material; influence of method of obtaining samples, time cream has been packed and manner of packing; comparison of results with cream and milk bottles; effect of emulsifying and homogenizing upon ease with which tests may be made. Okla.
5. Chemical and bacteriological studies of ice cream. Ind.
6. A study of the factors affecting swell in ice cream. Calif.
7. Factors affecting the formation of ice crystals in ice cream. N. Y. Cornell.
8. Fillers in the manufacture of ice cream. Wash.

Studies of milk secretion, composition and supply

1. An investigation of physiological and chemical changes taking place within the mammary gland during secretion. Md.
2. Certain problems relating to the biochemistry of milk formation in the udder. N. Y. State.
3. Milk secretion studies, using condemned tubercular cattle. The study of the source of milk solids. Vt.
4. Synthetic capacity of the mammary gland. Wis.
5. Feeding galactose to dairy cattle. Del.
6. The influence of barley on the milk secretion of cows. Calif.
7. Investigations into causes of variation in milk and fat production. Effect of individuality of cows upon milk and fat yields. Influence of alimentary carbohydrates on the yield and composition of milk. Effect of proteins from restricted sources on the yield and composition of milk. Iowa.

8. Factors influencing or affecting the chemical and physical properties of milk. Miss.
9. Analysis of milk records. To determine the age changes and the duration between total solids-not-fat and milk production, per cent fat, and butter fat. Maine.
10. Factors influencing the composition of milk; the influence of the plane of nutrition of the cow. Missouri.
11. A study of the composition of milk and fat—as affected by feeds, from different breeds of cows, and with reference to the natural quantitative relationship existing between the various constituents of milk. Ohio.
12. Study of the chemistry of butter fat and the affect of food in modifying its chemical and physical character. Mass.
13. The effect of peanut meal when fed to dairy cows on the qualities of the butter fat, and methods by which this feed may be fed without undesirable effects. Ga.
14. Study of carbonic acid in milk. N. Y. State.
15. Carbonic acid in milk under various conditions after being drawn from the udder, and carbonic acid content as a basis for distinguishing between heated and unheated milk. N. Y. State.
16. Carbonic acid and carbonates in the udder. N. Y. State.
17. Acidity of fresh milk. N. Y. Cornell.
18. Conditions affecting hydrogen-ion concentration in milk. N. Y. State.
19. Acid production and the rate of growth of the lactic acid organism in the souring of milk. N. Y. State.
20. Investigation in the eradication of onion flavors from milk. N. C.
21. The enzymes of milk and their relation to abnormal flavors. Mo.
22. Studies on the bacterial flavors and odors of milk. Iowa.
23. The toxicity of milk. (?)
24. Effect of diseases in the cow on milk. Mich.
25. The investigation of the food value for infants and invalids of various milks. Md.
26. Studies regarding the nutritive value of milk, its suitability for food for children and animals, conditions which affect its nutritive value, tolerance, and related questions. Vt.
27. Study of city milk supply. N. Y. Cornell.
28. Studies on method of controlling and standardizing the quality of market milk. N. Y. State.

29. The important factors in the production of sanitary milk and the means and methods of milk examination. N. Y. State.
30. Study in the quality of milk. Ore.
31. Tests for pasteurized milk. Wis.
32. Studies of minor factors in market milk distribution. Mich.
33. A study of the milk and cream supply furnished to the University Farm Creamery, with the object of working out a system of grading and paying for quality. Calif.
34. The marketing of dairy products, in Oklahoma. To ascertain general prices of butter fat, of milk and cream in all sections of the state at four periods of the year. The kind of market available; amount of butter fat, milk or cream offered for sale at centers in all sections of the State, methods of marketing, and form in which butter fat is marketed; frequency of market and the factors determining prices. Okla.
35. Shipments of dairy products in New York State. N. Y. Cornell.
36. Study of plant records. N. Y. Cornell.
37. The production, handling and marketing of milk and the making of butter under tropical conditions, Dairying in the tropic. Porto Rico.

Studies in milk testing

1. Official dairy testing. N. Dak. Wash.
2. Advanced registry testing. Va.
3. Comparison of fat tests made by cow testing associations and local creamery. N. Y. Cornell.
4. Composite *v.* one day testing of milk samples. N. C.

Studies of cost of milk production and accounting

1. Cost of milk production. Conn. Storrs. N. Dak. Ohio.
2. Cost of milk production in Nebraska. Nebr.
3. Procuring data relative to the cost of producing market milk. Mich.
4. Cost of milk production and dairy farm organization. Wash.
5. Cost of milk from forced *v.* averaged dairy condition cows. Md.
6. Records of production, cost of feeding, and cost of milk production in tests of advanced registry of dairy cows. To secure records of production of registered dairy cows in Oklahoma; to secure feed records and methods of feeding dairy cows when under official test; to determine the cost of feeding test cows in Oklahoma; to determine cost of production of milk in tests of advanced registry to owners or breeders of dairy cows. Okla.

7. Cost of producing dairy products. Minn.
8. Method and cost of distributing milk, with special reference to Oakland, Alameda, and Berkeley, Calif.
9. A study of the animal cost of the production of milk for the city supply and of butter fat for the creamery. Ill.
10. Dairy farm organization and cost of milk production. Wash.

Dairy Products Activities of the Dairy Marketing Division of the Bureau of Markets of the United States Department of Agriculture

(For the year 1919–1920 and 1921)

Investigational activities

Methods and cost of marketing dairy products

1. Methods of butter marketing by wholesalers and jobbers.
2. Methods of cheese marketing by wholesalers and jobbers.
3. Methods and costs of supplying cities with market milk and cream.
4. Methods of marketing cottage cheese by manufacturers and retailers.
5. Plan of organization and functions performed by producers dairy marketing organizations.

Market grades and standards for dairy products

1. Market grades and standards for creamery butter.
2. Market grades and standards for American (Cheddar) cheese.
3. Market grades and standards for cream.
4. Market grades and standards for market milk.
5. Market grades and standards for Swiss and brick cheese.

Inspection service activities

Market inspection service

1. Butter inspection service maintained in the Boston, Chicago, New York and Philadelphia markets under act of Congress known as the Food Products Inspection Act.
2. Informal inspections made of cheese in the New York markets.
3. Informal tests made of weight of shipments of butter at Boston, Chicago, New York and Philadelphia.

Market reports and market information

Dairy statistics (supplies and stocks)

1. Monthly reports of imports and exports of butter, cheese, condensed and evaporated milk, casein and milk powder.
2. Monthly reports (issued quarterly) of production of whey and creamery butter, American cheese, Swiss cheese, brick and Munster cheese, Limburger cheese, Cottage, pot and bakers' cheese, cream and Neufchatel cheese, all Italian varieties of cheese, and all other varieties of cheese, dried casein, all classes of condensed and evaporated milk, evaporated milk modified with foreign fat, condensed and evaporated butter milk, dried or powdered buttermilk, desiccated or powdered milk, malted milk, milk sugar and ice cream. Reports are also issued monthly on the production of process butter and oleomargarine.
3. Monthly reports of stocks of creamery butter, packing stock butter, American cheese, Swiss cheese, brick and Munster cheese, Limburger cheese, Cottage, pot or bakers' cheese, cream and Neufchatel cheese, and all other varieties of cheese in cold storage.
4. Monthly stocks of condensed and evaporated milk in hands of manufacturers, including separate figures for total and unsold stocks, unfilled orders, and unsold stocks held in New York City.
5. Daily receipts of butter and cheese at Boston, Chicago, New York, Philadelphia and San Francisco.
6. Daily movement of butter and cheese into and out of storage at Boston, Chicago, New York, Philadelphia and San Francisco.
7. Daily stocks of butter held as current trading stocks by wholesale butter dealers in Boston, Chicago, New York, Philadelphia and San Francisco.
8. Weekly reports of stocks of cheese held as current trading and storage stocks by cheese dealers in Boston, Chicago, New York, Philadelphia, San Francisco, and by primary market cheese dealers (over 90) in Wisconsin.

Prices of dairy products

1. Daily wholesale and jobbing prices of butter in Boston, Chicago, New York, Philadelphia, and San Francisco.

2. Daily wholesale prices of Number one American cheese (all styles) in Boston, Chicago, New York, Philadelphia, San Francisco and primary cheese markets in Wisconsin.
3. Monthly reports of prices paid milk producers for milk for city distribution in over 100 cities in the United States.
4. Monthly report of average prices paid milk producers for milk by condenseries in the various geographical sections of the United States.
5. Wholesale and retail prices of market milk and cream in over 100 cities in the United States.
6. Monthly report of average prices of condensed and evaporated milk in the various geographical sections of the United States.

Condition of markets for dairy products

1. Daily comments on butter markets, conditions in Boston, Chicago, New York, Philadelphia and San Francisco.
2. Daily comments on cheese market conditions in Boston, Chicago, New York, Philadelphia, San Francisco, and primary cheese markets in Wisconsin.
3. Weekly review of butter market conditions in the United States.
4. Weekly review of the cheese market conditions in the United States.
5. Monthly report of conditions in the condensed and evaporated milk market in the United States.

Research Activities of the Dairy Division of the Bureau of Animal Industry of the United States Department of Agriculture

(For the year 1919–20 and 1921)

Dairy research laboratory

1. Bacteria concerned in the ripening of Swiss cheese.
2. Utilization of lactose by fermentation.
3. Physiology, taxonomy and origin of the streptococci occurring in milk.
4. Manufacture and ripening of Roquefort cheese.
5. Manufacture and ripening of Camembert cheese.
6. Factors influencing texture of ice cream.
7. Utilization of whey for feeding purposes.
8. The precursors in the blood of milk proteins.

9. Bacteria concerned in the deterioration of condensed milk.
10. Influence of calcium and phosphorus deficiency on milk yield.
11. Factors influencing viscosity of condensed milk.
12. Methods of improving hand separator cream.
13. The manufacture and curing of the hard Italian cheeses.
14. The utilization of the albumen of whey.
15. Bacteria surviving sterilization in evaporated milk.
16. Factors influencing the coagulation of evaporated milk in sterilization.
17. The cause and control of sandiness in ice cream.
18. The cause and control of deterioration in milk powder.
19. Seasonal variation in milk for evaporating.
20. The influence of salts on the growth of bacteria.
21. Chemical and physical changes in milk coagulation.

Market milk section

1. Dairy sanitation:
   Sanitary surveys are made of milk supplies in various cities at the request of local officials.
2. Milk plant management:
   Studies are made of methods and costs of the various operations entailed in the handling and delivery of milk in cities.
   Special studies are made of some of the various specific problems the milk-plant manager meets.
3. Methods of cleaning milking machines:
   Studies as to the best methods of cleaning milking machines.
4. Milk transportation:
   Studies as to the best methods of transporting milk to the city with the least possible amount of loss from spoilage.
5. Special studies:
   Special studies of the various properties of milk products, such as, whipping quality of cream, etc.
6. Studies in the Unit Requirements for Producing Milk:
   Studies conducted for two years in each of seven different States.

Dairy extension section

(a) *Projects in cow testing association investigations*

1. Influence of production on income over cost of feed.
2. Relation of production to returns on $1.00 expended for feed.

3. Relation of production to feed cost per pound of butterfat.
4. Relation of production to feed cost per 100 pounds of milk.
5. Production as influenced by date of freshening.
6. Influence of size within the breed.
7. Effect of location.
8. Length of time large producers remain in the service, as compared with production period of low producers.
9. Decrease in production as lactation period progresses.
10. The cow as an economical producer of human food.
11. Increased production due to testing done by the association.
12. Relation between profit and the feeding of silage.
13. Relation between profit and the feeding of legumes.
14. The feeding of timothy.
15. Influence of pasture.
16. Summer dairying.
17. Daughters of purebred sires compared with the dams of the daughters.
18. Influence of age on production.
19. Production of milk and butterfat in relation to the butterfat test.
20. Variation in butterfat test due to season.
21. Variation in butterfat test due to point of lactation period.
22. Percentage of cows that fall below 3.25 per cent in the test.
23. Percentage of herds that test less than 3.25 per cent butterfat.
24. The tester and his work.

(b) *Investigations and study of coöperative bull associations*

1. Problems connected with methods of organization and development.
2. Study of the relative cost of bull service before and after organizing.
3. Studies of the results of the use of better bulls on herds belonging to members of bull associations.
4. Study and investigation of the problems and methods of handling vicious and unruly bulls as affecting the bull association organizations.
5. Study of the abortion disease as affecting bull association organizations.

(c) *Study of cheese and cheese making*

1. Mountain cheese work in mountains of the south.
2. Studies and problems involved in the introduction of Swiss and other foreign cheeses into commercial factories.

Dairy Division experiment farm

1. Effects of the various feeds and constituents of feed upon the animal body, upon growth, and upon the yield and composition of milk, and to find out the relative values of feeds for dairy production.
2. Effect of regular versus irregular milking.
3. Effect of milking two, three and four times per day.
4. Effect of keeping cows in stanchions versus box stalls.
5. Feed cost of raising heifers.
6. Raising calves on milk substitutes.
7. Feeding sweet potato meal to dairy cows.
8. Growing crops for the silo.

Breeding experiments (dairy cattle)

1. Comparing line breeding with the mating of unrelated animals; comparing in-breeding with the mating of unrelated animals, as a means of fixing high production in dairy cattle; also the effect of these methods of breeding on constitution, fertility and type.
2. An attempt to fix prepotency for high production by continued use of sires that have shown the ability to get high-producing daughters, for generation after generation.
3. Statistical study of the effect of methods of breeding on production, from advanced register and register of merit data.

Dairy manufacturing section

1. Study of butter manufacturing costs.
2. Study of condensed milk manufacturing costs.
3. Study of cottage cheese manufacturing costs.
4. Study of Camembert cheese manufacturing costs.
5. Study of Roquefort cheese manufacturing costs.
6. Study of Swiss cheese manufacturing costs.
7. Study of losses in creamery receiving rooms.
8. Study of losses in butter manufacture.
9. Study of losses in Swiss cheese manufacture.
10. Study of losses in condensed milk manufacture.
11. Study of cream hauling problems.

Miscellaneous

1. Collection of dairy statistics; charting data obtained, and interpretation of statistics.
2. Experiments in temperature control in connection with dairy manufacturing.
3. Experiments in humidity control.
4. Experiments in heat transmission.
5. Problems in refrigeration in connection with dairy manufacturing plants.

IN HOW FAR IS THE BACTERIAL COUNT OF MILK INFLUENCED BY THE DIRT CONTENT?

H. A. HARDING, M. J. PRUCHA, E. F. KOHMAN, H. M. WEETER AND W. H. CHAMBERS

Dairy Husbandry Department, Urbana, Illinois

Almost every one has an opinion regarding the influence of the visible foreign matter, commonly referred to as dirt, upon the bacterial count of milk and these opinions fall into two groups, the larger of which supports an old view and the smaller one a modern one.

The old view is illustrated by the fact that much of the past advice to the producer and dealer who are striving for a milk of low germ content may be summarized in the injunction, "Get it clean and keep it cold." In many of our cities, milk ordinances have been enacted setting limits to the permissible bacterial count of milk, with the avowed object of providing a clean milk supply. In some cases the authorities delegated to enforce our pure-food laws have taken the position that the presence of large numbers of bacteria in milk is evidence of filthy conditions of production or handling. Accordingly, it is natural that the general public should regard a milk which sours quickly as dirty and, therefore, objectionable from the æsthetic and sanitary standpoint.

On the other hand, the modern view has been based upon certain facts which have suggested that dirt has but slight influence upon the bacterial count. Where market milk has been scored both on its content of visible dirt and on its bacterial count, no well marked relation has been found between the dirt score and the bacterial count. Apparently the milk containing evident dirt is about as likely to have a low bacterial count as are other samples.

The importance of the keeping quality of milk has led to studies of the source of its bacterial life. It has been established that in a few cases the udder of the cow makes large additions to this bacterial life (1) but that ordinarily the udder contributes about 500 per cubic

centimeter (2). It has also been shown that in warm weather, utensils which are well washed and steamed but not promptly and thoroughly dried, when used some hours later contribute 30,000 or more per cc. to the bacterial count of the milk. (3). The morning's milk as it is delivered from the farm to the milk plant often shows a bacterial count of approximately 50,000 per cc. (4). The much higher numbers which are later found in this same milk are the result of growth. There is no known relation between the dirt content and the bacterial count due to the udder, between the dirt content and the bacteria from the well washed utensils, or between the dirt and the rate of bacterial growth in the milk. Inasmuch as udder flora, utensils, and growth seem to account for practically all the bacteria found in city milk supplies, it is hard for those holding the modern view to believe that the dirt content exerts a controlling influence over the bacterial content of milk.

The accumulation of this kind of circumstantial evidence has led to the gradual development of a new point of view regarding the relation of dirt to the bacterial count of milk. This point of view is indicated in the following quotation from Third Revision of the Standard Methods for the Sanitary Analysis of Milk as approved by the Laboratory Section of the American Public Health Association at the San Francisco meeting, September, 1920.

> *Because much of the dirt* that appears as a visible and insoluble sediment *in milk is accompanied by relatively few bacteria in proportion to the number derived from other sources,* it frequently becomes desirable to use a test that will reveal the amount of visible sediment in the milk. For this reason the committee has included a description of the commonly used sediment test. *It is only by using this sediment test* in conjunction with the bacterial count *that it is possible to prevent the occasional approval of dirty milk.*[1]

Considering the practical importance of this matter, there is a surprising lack of data regarding the relationship of dirt to bacterial count. The old idea that the dirt content exercises a controlling influence over the bacterial life in the milk rests partly upon the fact that dirt always carries bacteria and partly upon the fact that the dirt has been lon g said to control the bacterial content.

[1] Italics are our own.

Any belief which is held by so large a number of intelligent people should be treated with respect, but at the same time the important relation which this matter sustains to the milk business makes it very desirable that the facts in the case be determined. The following data are submitted with the hope of furnishing a more substantial basis for the discussion of this question.

INCREASE IN BACTERIAL COUNT DUE TO DIRT FROM FAIRLY CLEAN COWS

While dirt may enter milk at any stage on its journey from the cow to the consumer, the milk is normally protected by being placed in covered cans almost immediately after it is drawn from the cow. Accordingly, the entrance of dirt, at least at the farm, is practically restricted to the milking process and the main source of dirt is the material falling from the coat of the cow.

During 1914–1915 a study was made of the bacterial count of the milk from the cows in three barns. This milk was drawn by hand in the ordinary way into small-topped milk pails, having an oval opening 5 by 7 inches. The pails had been thoroughly steamed and protected from contamination up to the beginning of the milking process. The samples for bacteriological study were taken from the pail when the milker brought it from the barn into the adjoining milk room. Examinations were also made of the udder flora of the cows. This study included 1665 samples. (For details see Bulletin 199 (5) of this station.)

In barn I, in which the general conditions of cleanliness were comparable with conditions in some certified milk barns, the bacterial count of the milk, if that from one abnormal cow be omitted, averaged about 1,000 per cubic centimeter. Since this represented the combined influence of the udder flora and of the dirt, the influence of the dirt may be obtained by subtracting the 500 per cubic centimeter which has been found to be a normal figure for the udder flora of normal cows. On the basis of this calculation, the dirt falling into the milk in this barn increased the bacterial count by approximately 500 per cubic centimeter.

In barn II the general conditions of the barn and cows were comparable with those of the better market milk dairies. Here again, the milk as it came from the barn showed a bacterial count of approximately 1,000 per cubic centimeter. The udder content of the cows was normal, and making the deduction of 500 per cubic centimeter for udder flora leaves 500 per cubic centimeter as the increase due to dirt entering the milk. The explanation of these identical results in two barns which appeared to be quite different in their cleanliness lies in the fact that in both barns the cows were well bedded and were clean and in both cases hair and dandruff from the cows fell into the milk during the milking process.

In barn III conditions were quite different. This barn had a dirt floor and no provision for drainage, and the cows were allowed to run loose in it except at milking time. Straw was added to absorb the liquid and cover the manure and the resulting accumulation became two to four feet deep before it was removed twice a year. Straw was supplied abundantly, and in the main the coat of the cows remained fairly clean, though the condition of the stable floor and, to some extent, the coat of the cows would undoubtedly have called forth a protest from a city milk inspector. The conditions of cleanliness were roughly comparable with those of ordinary dairies during the winter season. The average bacterial count of 238 samples of milk from this barn was 5,775 per cubic centimeter. As the bacteria from the udder of the cows in this barn gave a bacterial count of about 1,000 per cubic centimeter, the bacterial count due to the dirt amounted to approximately 4,500 per cubic centimeter.

EFFECT OF DIRT FROM EXTREMELY DIRTY COWS

The barn conditions already studied are representative of dairy conditions ranging from very good to rather questionable. In order to cover the subject it was desirable to study the milk produced by extremely dirty cows. It is the unwritten law of public institutions that dairy cows must be kept clean, and accordingly it was difficult to provide suitable material

for such a study. In the work already described, the cows were allowed to become so dirty as to provoke unfavorable comment.

In the winter of 1916, taking advantage of a quarantine due to a neighboring outbreak of foot-and-mouth disease, the cows in barn III were allowed to become extremely dirty. The accumulation of manure on the floor of the stable in which the cows

FIG. 1. SHOWING THE CONDITION OF THE COAT OF COW 1033 DURING THE PERIOD WHEN SHE WAS NOT CLEANED

were loose became about 4 feet deep. Practically no attempt was made to clean the cows for some months. Dirt and dried feces accumulated on the flanks and abdomens of the cows and they were fairly representative of extremely dirty conditions. The condition of the coat of one of these cows is shown in figure 1.

When the condition of the cows had become representative of extremely dirty conditions, the study of the milk was begun.

This study included a determination of the bacterial count and the dirt content of the milk of seven cows. The determinations of the bacterial count were made in three series of 10 milkings each, and in addition the bacterial count of the milk directly from the udder of each cow was determined at 6 separate milkings. Unfortunately the difficulties of determining the dirt content were such that it was accomplished at a total of only 24 milkings. Bacterial counts were made from a total of 252 samples.

The three series differed from each other in that in the first series of milkings from the extremely dirty cows, the milk pail was the small-topped one, with an oval opening 5 by 7 inches, used in the previous studies in barns I, II, and III; in the second series the cows were extremely dirty and an ordinary open-topped pail, having a diameter of about 12 inches, was used; and in the third series conditions were the same as in the first except that the coat of the cows had been thoroughly cleaned. The milk pails, in all cases, were carefully steamed and protected until used.

The sample for determining the bacterial count of the milk was taken from the milk of each cow as the milk came in the pail from the stable to the milk room. The dirt determinations were made from the unstrained milk, collected in eight-gallon cans. The total weight of this milk at each milking varied between 112 and 168 pounds.

Determining the dirt in the milk. A combination of sedimentation and centrifugal force was used in determining the amount of dirt. After the cans of milk had stood for eight hours, the bulk of the milk was siphoned (the first five samples were poured) through a weighed, 100-mesh to the inch sieve. The remaining milk was poured through the same sieve but collected in a glass cylinder. The cans were then rinsed and the rinsings poured through the sieve into the cylinder. The sieve was washed with water and a little alcohol to free it from milk and fat and these washings were added to the cylinder. The sieve was then dried and weighed. The material retained by the sieve was largely hair, and bits of straw, and what appeared to be scales from the skin of the cow.

Corrosive sublimate was added to the material in the cylinder as a preservative, and after the cylinder stood eight hours the upper portion of the fluid was siphoned off. The remaining material was centrifuged for half an hour, the liquid poured off, the sediment again suspended in distilled water and the centrifuging repeated. The liquid was then poured off and the sediment washed into a weighed, folded filter, dried, and weighed.

Series I. When the small-topped pail was used. In order to get information comparable with that from the earlier studies in barns I, II, and III, the small-topped pail was used in this

TABLE 1

Dirt and bacterial count from milk, drawn from dirty cows, into small-topped pails

DATE	MILK	DIRT				BACTERIA PER CUBIC CENTIMETER
		On sieve	On filter	Total	Per quart	
	pounds	*mgm.*	*mgm*	*mgm.*	*mgm.*	
February 24, a.m.	162.1	236.6	250.7	487.3	6.5	12,734
February 24, p.m.	148.1	727.2	259.6	986.8	14.3	8,416
February 25, a.m.	167.7	518.4	66.2	584.6	7.5	12,400
February 25, p.m.	148.9	352.4	96.2	448.6	6.5	12,115
February 26, a.m.	161.1	512.7	83.8	596.5	8.0	17,896
February 29, p.m.	142.1	370.0	133.9	503.9	7.6	14,800
March 1, a.m.	158.7	435.6	82.5	518.1	7.0	19,577
Average per quart		6.2	1.9		8.1	
Average per cubic centimeter						14,000

first series of samples. The average of the bacterial count from 70 samples of the milk from individual cows averaged 12,954 per cubic centimeter. Fifty-nine samples direct from the udders of these cows gave an average bacterial count of 964. Accordingly, the bacterial count due to dirt falling from these extremely dirty cows during the milking process, into small-topped pails, averaged 12,000 per cubic centimeter.

The dirt content of the milk was determined at seven milkings, and the results of these determinations as well as the bacterial count of the milk in which the dirt was determined is given in table 1.

As shown in table 1, the dirt collected on the sieve represents the dirt falling into the milk and later removed by careful straining. It consisted of bits of straw and hay, hair, dandruff, and coarse particles. At the second milking it included a large piece of hay which made up the larger part of the material. It will be noted that the material removed by the sieve averaged 6.2 mgm. per quart of milk. The finer material which passed the sieve represents the dirt which ordinarily remains in the milk unless removed by the clarifier or similar means. In these seven tests this material averaged 1.9 mgm. per quart. The total dirt recovered from this milk from extremely dirty cows when drawn into a small-topped pail averaged 8.1 mgm. per quart, or if the milking in which the large piece of hay fell be omitted, the average would have been 7.1 mgm per quart. The bacterial count of the milk was fairly uniform, varying from 8,500 to 19,500 per cubic centimeter. It will be noted that the smallest bacterial count was from the milk containing the largest proportion of dirt, but it has already been explained that this dirt consisted of a piece of hay, which was undoubtedly low in bacterial count. Had the milk from these seven milkings been blended together, it would have had a bacterial count of 14,000 per cubic centimeter.

In this connection it should be noted that this bacterial count was made after the plates had been incubated for five days at 20°C. and two days at 37°C. instead of the single incubation for two days at 37.5°C. as required by the official methods for routine milk examinations. This longer incubation period has been used consistently in all of these studies because it gives distinctly higher bacterial counts. Accordingly, had these samples of milk been given the official routine bacteriological examination, the majority of them would have shown bacterial counts below 10,000 per cubic centimeter, which marks the upper limit for certified milk.

Series II. When the ordinary milk pail was used. In commercial dairies, under the exceptional conditions where the cows would be permitted to become as dirty as those in this study, the ordinary open milk pail would be used. Under these conditions

the maximum amount of dirt would fall into the pail. In order to measure the dirt under the worst conditions, the seven cows were milked into open-topped pails for ten successive milkings. Samples representing the milk of each gave an average bacterial count of 18,229 per cubic centimeter. Forty-six per cent of the samples gave a bacterial count below 10,000 per cubic centimeter, and there was but one sample among the seventy with a bacterial count above 60,000, which marks the upper limit for New York Grade A milk.

TABLE 2

Dirt and bacterial count from milk, drawn from dirty cows, into open-topped pails

DATE	MILK	DIRT				BACTERIA PER CUBIC CENTIMETER
		On sieve	On filter	Total	Per Quart	
	pounds	*mgm*	*mgm*	*mgm*	*mgm*	
March 1, p.m.	140.0	574 1	107.7	681.8	10.5	22,179
March 2, a.m.	162 1	871.7	108 1	979.8	13.0	9,164
March 2, p.m.	143.8	695.6	66.9	762.5	11 4	17,470
March 3, a.m.	158 0	562.7	98 4	661.1	9 0	15,959
March 3, p.m.	140 5	589.9	75 5	665 4	10.2	17,929
March 6, p.m.	149.2	1103 5	119 5	1223 0	17 6	8,250
March 7, p.m.	132 8	1029.9	271 4	1301.3	21.1	35,623
March 8, p.m	150.7	1309.2	157.7	1466.9	16.6	22,303
Average per quart		12.4	1.8		14.2	
Average per quart omitting last three		9.5	1.3		10.8	
Average per cubic centimeter						18,244

The dirt content of the milk was determined at eight milkings and the results of these determinations as well as the bacterial count of the milk is given in table 2.

Of the dirt determinations shown in table 2, it is evident that the last three samples are abnormal. The results are given here just as determined even though the reason for the abnormality was understood at the time of determination. On these three days the milk promptly became ropy, and it was not possible to separate all of it from the sediment. The difficulty is most evident in material retained by the sieve, though the results from the filter were also affected. If these abnormal

results were included, the sediment per quart would average 14.2 mgm.; or if the calculations were restricted to the five days when conditions were normal, the average dirt content would be 10.8 mgm. per quart. The bacterial counts show that at two milkings the entire product of the seven cows had a bacterial count of less than 10,000 per cubic centimeter, and that at no milking did the count go above 36,000 per cubic centimeters. The average bacterial count for the entire 1,177 pounds of milk was 18,244 per cubic centimeter.

Series III. When the cows had been cleaned. In series I and II are given the germ count found and the dirt recovered from the milk of seven extremely dirty cows when they were milked into small-topped and into ordinary pails. The cows were dirty as a result of their lying upon an accumulation of straw and their own manure, which at the time of the study was about four feet deep.

In order to bring out more clearly the effect of the condition of the coat of the cow upon the cleanliness and the bacterial count of the milk, the coats of the cows were cleaned and all the other factors in the situation allowed to remain unchanged. For ten successive milkings these cleaned cows were milked into small-topped pails and the bacterial count and the dirt content were determined as in the preceding series. Only 15 per cent of the 68 samples gave a bacterial count of over 10,000 per cubic centimeter, and the average of all the samples was 7,165 per cubic centimeter.

The dirt content as determined at nine milkings as well as the bacterial count of the milk is given in table 3.

The coats of the cows were thoroughly cleaned before starting this series of samples. Then before each milking, the milker made some effort to remove the dirt evident upon the cow, and the resulting cleanliness of the cows was in sharp contrast to their former condition. Sufficient labor was not available, however, to keep the coats of the cows clean when they were living on the top of a manure heap. It will be noted from table 3 that at the first three milkings the dirt content of the milk steadily increased. Since this milk was drawn into small-topped

pails, the results in table 3 are directly comparable with those in table 1, the single difference being that the coats of the cows had been cleaned.

The total dirt recovered from the milk of the cleaned cows was 4.6 mgm. per quart, as against 8.1 mgm. recovered from the milk of the extremely dirty cows. Likewise the average bacterial count of 7,117 per cubic centimeter from the milk of the cleaned cows is comparable with 14,000 per cubic centimeter in the

TABLE 3

Dirt and bacterial count from milk, drawn from cleaned cows, into small-topped pails

DATE	MILK	DIRT				BACTERIA PER CUBIC CENTIMETER
		On sieve	On filter	Total	Per quart	
	pounds	*mgm.*	*mgm.*	*mgm.*	*mgm.*	
March 17, a.m.	145.6	160.6	7.6	168.2	2.5	3,490
March 18, a.m.	143.3	208.7	26.0	234.7	3.5	17,219
March 18, p.m.	128.1	210.8	54.5	265.3	4.5	5,379
March 20, a.m.	126.4	142.6	60.1	202.7	3 4	3,672
March 20, p.m.	112.4	249.8	56.8	306.6	5.9	6,473
March 21, a.m.	148.7	222.3	48.9	271.2	3.9	5,650
March 21, p.m.	134.4	415.1	79.1	494.2	7.9	6,382
March 22, a.m.	155 0	103.3	75.6	178.9	2.5	6,086
March 23, a.m.	146.7	392.9	26.1	419.0	6.2	9,108
Average per quart		3.8	0.8		4.6	
Average per cubic centimeter						7,117

milk of the extremely dirty cows. Allowing 1,000 per cubic centimeter as the bacterial count due to the udder, these results indicate that cleaning the coat of the cows resulted in a 44 per cent reduction in the dirt content and a 46 per cent reduction in the bacterial count. It chanced that two of the highest bacterial counts of the series occurred in the samples on the morning of March 18, and the average bacterial count for that milking was 17,219. The combined average for the bacterial counts of the other eight milkings was but 5,780 per cubic centimeter.

BACTERIAL COUNT OF THE DIRT FROM EXTREMELY DIRTY COWS.

The smallness of the increase in the bacterial count of the milk in these series of tests, that was due to dirt falling from the extremely dirty cows will undoubtedly be a surprise to all and perhaps something of a disappointment to those who hold that dirt is a large source of germ life in milk.

It may be suggested that for some reason the dirt from these cows did not furnish a large bacterial count. However, the amount of milk, the dirt content, and the germ count are all known with regard to each of the three series of tests, and from those data it is possible to compute the bacterial count of the dirt recovered from the milk. This may be done by computing the total germ count of the milk, subtracting the 1,000 per cubic centimeter due to udder flora, and dividing the resulting number by the grams of dirt. The data for this calculation for each of the three series are given in table 4.

TABLE 4

Bacterial count of dirt recovered from the milk

SERIES	VOLUME OF MILK	DIRT FOUND	GERMS IN MILK	GERMS FROM UDDER	GERMS FROM DIRT	GERMS FROM 1 GRAM OF DIRT
	cc	*gm*				
I	478,537	4.1258	6,699,610,147	478,537,000	6,221,073,147	1,507,840,000
II	327,162	3.7506	5,338,981,994	327,162,000	5,011,819,994	1,341,600,000
III	545,765	2.5408	3,884,347,760	545,765,000	3,338,582,760	1,313,980,000

The data in table 4 place the bacterial count of the dirt recovered from the milk at approximately 1.5 billions per gram. Those who are familiar with the bacterial count of milk and surface soil will at once recognize that this is a high figure. In fact it is so high that those who feel that the amount of dirt recovered from the milk was too small may suggest that this large amount of bacterial life may have entered the milk in connection with a larger amount of dirt than was later recovered from the milk.

Manifestly the most direct means of determining the bacterial count of the dirt falling from the udder and flank of the cow during the milking process is to secure some of this dry material directly from the cow and determine its bacterial count.

This plan was followed, two cows in two different barns being used for the purpose. Cow 152 in barn I had been brushed daily, and her coat showed no visible dirt. She was representative of very clean cows. Cow 1039 in barn III was an extremely dirty cow. Her condition and surroundings were the same as the seven cows in series I and II. Her flank and abdomen were partially covered with dried manure.

Neither cow was in milk, and the samples were collected by using a sterilized, open-top milk pail. Any loose bedding on the flank or udder was brushed away by hand, as is customary before milking, but the cows were not otherwise prepared for the tests. The pail was held partially under the cow, as would be done during ordinary hand-milking, and the udder mani-pulated as though the cow was being milked. In the first two tests the manipulation was continued for seven minutes and in the three others for ten minutes. The pail was then taken to the laboratory and the visible dirt brushed out and weighed. The dirt was then mixed with a definite amount of milk and after being mixed for fifteen to twenty-five minutes, plates were prepared for determination of the bacterial count.

The results of five such determinations are given in table 5.

From table 5 it is seen that the clean and the dirty cows were quite unlike both in the amount of dirt falling into the pail and in the bacterial count per gram of dirt. In other words, the dirt from a dirty cow is not only more abundant but it is also a different kind of dirt with a much higher bacterial count per gram.

In removing the dirt from the pail during the experiment it was noted that the dirt falling from cow 152 consisted of some hair and fine dandruff. The dirt from cow 1039 was made up of considerable hair, dandruff, and many fine particles of dirt, presumably in part dried manure. Because of the distinctly different bacterial count of the material from the two cows, interest is at present centered upon the results from cow 1039, since she was a companion cow with the seven dirty cows in barn III.

It will be noticed that four tests of this cow on successive days gave widely differing results, not only in amount of dirt collected,

but in the bacterial count per gram of this dirt. While this variation is undoubtedly due in part to the varying bacterial count of the different kinds of dirt finding their way into the pail, it is also due in part to the difficulty of getting representative samples of the material in making the plates. In preparing the samples, the dirt was placed in measured amounts of milk varying from 500 to 5,000 cubic centimeters, and after fifteen minutes, with thorough shaking, samples were taken for plating within the following ten minutes. The number of samples taken, from which dilutions and plates were made, varied from two to twenty on the different days and six to nine plates

TABLE 5.
Bacterial count of dirt from coats of cows

NUMBER OF COW	CONDITION OF COW	DIRT FROM MILK PAIL	GERM COUNT OF DIRT	GERM COUNT PER 1 GRAM
		gm.		
152*	Clean	0.043	766,000	17,814,000
1039*	Dirty	0.240	94,285,000	392,800,000
1039	Dirty	0.108	496,000,000	4,592,000,000
1039	Dirty	0.083	15,300,000	184,000,000
1039	Dirty	0.171	293,475,000	1,716,000,000

* In these two tests the manipulation of the udder was continued but seven minutes while in the other three the manipulation lasted ten minutes. To facilitate comparison, the amount of dirt and its bacterial count were increased to a ten-minute basis. This did not affect the final computation of bacterial count per gram of dirt.

were made from each sample. Not all of these plates could be counted, but the bacterial counts given for the four tests of cow 1039 are based upon counts from 11, 20, 13, and 46 plates respectively. The fact that in these experiments the dirt was suspended in less than one-tenth the volume of milk in which it would be suspended in ordinary milking undoubtedly added to the difficulty of getting accordant bacterial counts.

It is plain that little can be gained by considering a mathematical average of bacterial counts which vary as widely as those in table 5. At the same time it is clear that if a large number of such determinations were averaged, as was done with each of the three series of samples from barn III, it is altogether likely

that such an average would show a bacterial count for the dirt of at least 1.5 billions per gram.

Accordingly, in so far as conclusions can be drawn from such a limited number of observations, these direct examinations of the dirt falling into the milk pail from a dirty cow suggest that the visible dirt recovered from the milk in the three series of experiments was sufficient in amount to account for the accompanying increase in the bacterial count of the milk. In other words, these results tend to show that the methods employed in recovering the visible dirt from the milk recovered essentially all of the dirt.

In the case of three of these suspensions, where a known amount of dirt was suspended in 500 cubic centimeters of skim milk, advantage was taken of the opportunity to test the extent to which it is possible to recover this dirt by filtration through cotton. In each case the weight of the cotton filter after filtration and drying was found to be increased by an amount slightly in excess of the weight of the dirt added to the milk. Evidently the milk adhering tenaciously to the cotton more than offset the weight of any dirt which went into solution or passed through the cotton. As the technique employed in the case of these 500 cc. suspensions was different from that employed in removing the dirt from the larger quantities of normal milk, they throw little light upon the accuracy of the other method except to suggest that the element of solubility is not large in the case of the dirt falling into the milk from extremely dirty cows.

SUMMARY AND CONCLUSIONS

Practically all of the dirt entering the milk at the farm enters during the act of milking.

The use of a small-topped milk pail materially reduces the amount of dirt entering the milk, the reduction varying from 25 to 40 per cent.

These studies show that the weight of the dirt entering the milk during the milking process is surprisingly small. Even when the cows were extremely dirty and were milked into an open-topped pail, the dirt in the unstrained milk amounted to only about 10 mgm. per quart. When the conditions were comparable

with those of ordinary dairies and the small-topped pail was used, the dirt in the milk was less than 5 mgm. per quart. Under conditions comparable with the better class of market milk dairies and where the small-topped pail was used, the proportion of dirt was not over 2.5 mgm. per quart.

The kinds of dirt falling into the milk vary with the condition of the coat of the cow. With hand milking, the entrance of some hair and dandruff is practically unavoidable, though the amount may be reduced by regularly brushing the coat of the cow. If the flank or udder is soiled with dried manure and other dirt, some of this may find its way into the milk.

Thorough straining removes the hair, dandruff, and larger particles, which form 75 to 90 per cent of the visible dirt.

Undoubtedly some of the dirt goes into solution in the milk, but the amount was so slight that we did not succeed in measuring or even in detecting it.

The increase in the bacterial count due to dirt entering the milk varies widely with the nature of the dirt. Hair and dandruff from clean cows have much less effect upon the bacterial count than dirt from extremely dirty cows.

The germ life on dirt from extremely dirty cows gave a bacterial count of approximately 1.5 billion per gram of dirt. Under the worst conditions, when the dirt in the milk amounted to 10.8 mgm. per quart, the increase in bacterial count of the milk was about 17,000 per cubic centimeter. Under the same conditions except that the small-topped pail was used, which reduced the dirt entering the milk to 8.1 mgm. per quart, the bacterial count due to dirt fell to 13,000 per cubic centimeter.

Previous studies have shown that in warm weather the use of clean utensils which have not been promptly and thoroughly dried results in an immediate increase of the germ count of the milk varying from 30,000 to 1,000,000 per cubic centimeter. In the summer season the milk drawn in the morning and delivered from the farm to the milk plant has an average bacterial count of at least 50,000 per cubic centimeter. After the first six to ten hours, growth begins and may rapidly increase the bacterial count.

In view of these facts, it is plain that variations in the bacterial count as large as 17,000 per cubic centimeter due to dirt, at least in the summer season, will be promptly overshadowed by other factors. When the time interval permits growth, any attempt to judge of the conditions of cleanliness surrounding the production of a given sample of milk on the basis of its bacterial count becomes hopeless.

When the results of this study are properly understood, it will be clear that they can not be used legitimately as an excuse for the production of dirty milk.

These studies show that where the germ count is relied upon to protect the consumer against dirty milk, the consumer will not be protected. It is entirely possible for the dirtiest milk to pass the most stringent standards based on bacterial counts which have been established in connection with the supervision of municipal milk supplies.

While it is still an open question as to what may ultimately be accepted as the most satisfactory index for the keeping quality of milk there is no question but that when the bacterial count is properly determined it is a serviceable index for this purpose. It is not. however, an index by which the presence of dirt can be determined, for the bacteria are commonly so numerous in milk and come from so many sources other than dirt that there is no constant relation between the dirt content and the number of germs present. Such being the case, the conclusive demonstration of the uselessness of bacterial counts as a means of detecting the presence of dirt is the necessary first step toward developing methods for accurately safeguarding the public against dirty milk.

As has been repeatedly pointed out in this publication and in the report of the Committee of the American Public Health Association already quoted, if the public is to be protected against dirty milk it must be, not through attention to bacterial counts, but through attention to measurements of the dirt actually present.

The measurements herein reported are respectfully submitted as a pioneer attempt looking toward the ultimate formulation of reasonable and helpful standards for clean milk.

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THE VARIATION IN THE PER CENT OF FAT IN SUCCESSIVE PORTIONS OF COW'S MILK[1]

A. C. RAGSDALE, SAMUEL BRODY, AND CHARLES W. TURNER

Department of Dairy Husbandry, University of Missouri, Columbia, Missouri

The fact that successive portions of milk drawn from a cow gradually increase in fat content has long been known by the practical dairyman and recently verified by a large number of investigations (1) on man, ox, and goat. This increase in fat content of successive fractions of milk was formerly explained (2) by the action of gravity, the lighter fat rising to the top of the milk cistern and ducts, leaving the bottom milk poorer in fat. This gravity theory was discarded due to the estimations of Heidenhain (3) that the glandular capacity of the udder as determined by the difference in its volume before and after evacuation of milk is much below the volume of milk given by a cow during one milking, and his consequent inference that milking activates the secretion of milk, a large part of the milk being secreted during the process of milking. If Heidenhain's inference is correct then of course the gravity theory can not be used to explain the variation of fat in the last fractions of milk which are largely secreted during the process of milking, and the explanation current since Heidenhain's time is that the forward movement of the fatty globules is retarded through congestion and friction and come down completely only as the last portions of the milk are drawn off.

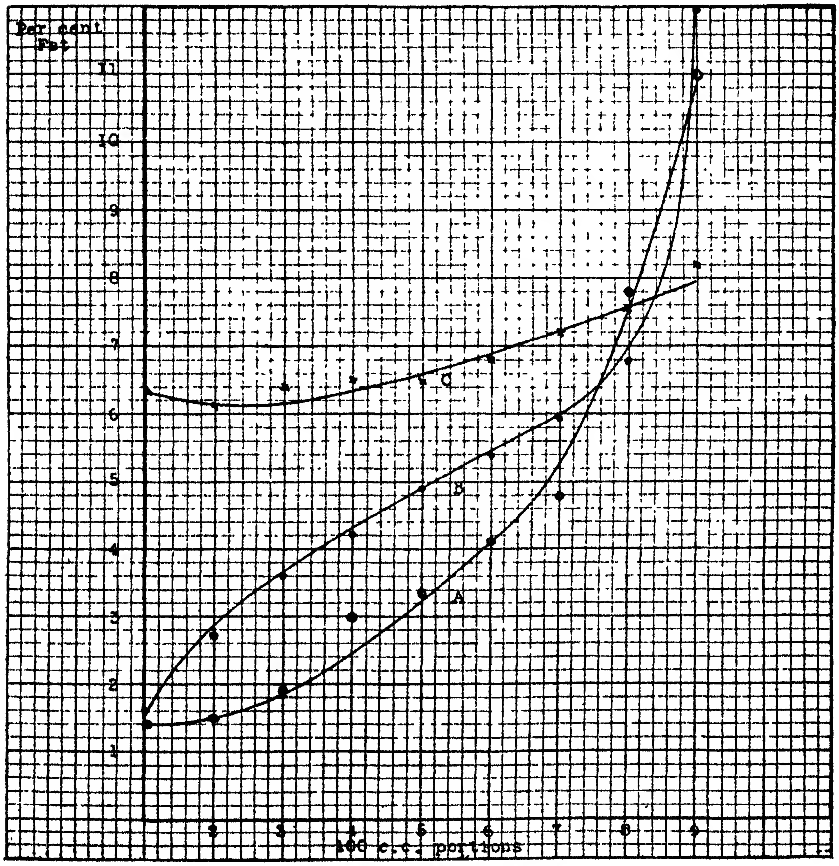
The object of this paper is to present a rather striking fact bearing on this subject which may, with further accumulation of data, contribute to an explanation of the phenomenon. The right front quarter of a Jersey cow producing about 20 pounds of milk per day was milked under the following conditions:

[1] Published with the permission of the Director of the Missouri Agricultural Experiment Station.

a. Immediately on coming into the barn from the pasture.

b. After standing quietly in the barn for two hours.

c. After standing quietly in the barn for two hours followed by a thorough massaging and manipulation of the udder for a few minutes for the purpose of "mixing" the milk within if such is possible.



GRAPH SHOWING THE VARIATION IN THE PER CENT OF FAT IN SUCCESSIVE PORTIONS OF MILK

A, Drawn from a cow after standing in the barn for two hours; B, Drawn from a cylinder after standing for three hours; C, Drawn from a cow after standing in the barn followed by a manipulation of the udder.

The milk in each case was drawn into a 100 cc. cylinder and fat determined in each of the 100 cc. fractions. For comparison determinations were made on the variations of fat in successive 100 cc. fractions of milk drawn from a 900 cc. cylinder of the usual dimensions after standing for one and a half hours and for three hours. The figure and table giving the results obtained show that within the given limits the longer the cow stands quietly, the greater the variations in fat; and the same is true of the cylinder milk—the longer the cylinder is allowed to stand the greater the variations in fat, as would naturally be expected. The curves of variation of fat in the cylinder and udder are strikingly similar. This tempts the suggestion of the possible correctness of the old gravity theory.

SAMPLE NO.	COW			CYLINDER	
	Upon coming into barn	After standing two hours	Standing two hours and manipulation	After standing one and one-half hours	After standing three hours
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
1	3.1	1.4	6.3	4.4	1.6
2	3.2	1.5	6.1	5.4	2.7
3	4.7	1.9	6.4	5.7	3.6
4	5.4	3.0	6.5	5.8	4.2
5	5.9	3.4	6.5	5.9	4.9
6	6.6	4.1	6.8	6.0	5.4
7	6.9	4.8	7.2	6.0	5.9
8	6.5	7.8	7.5	6.3	6.8
9	6.8	11.0 (app.)	8.2	6.7	12.0

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MILK PRODUCTION OF YOUNG COWS COMPARED WITH THAT OF MATURE COWS

J. J. HOOPER

Department of Animal Husbandry, University of Kentucky, Lexington, Kentucky

The question is often asked as to how much more milk will a mature cow yield than a two-year-old cow with her first calf. In other words, if a heifer produces 6700 pounds of milk and 360 pounds of butter fat during her first year's milking, how much will she yield as a mature cow, and at what age will she mature, or at what age will she produce the largest quantity?

To determine this matter I studied the yearly official test records of 865 Jersey cows, so my work relates only to that breed, although it holds good in a general way for all dairy breeds.

The records are as follows:

Production of young cows compared with that of mature cows

AGE OF COW	NUMBER OF COWS	MILK	PER CENT	BUTTER FAT	PER CENT
year		*pounds*		*pounds*	
1	86	6,267	68	337	71
2	278	6,707	74	359	73
3	126	7,496	82	399	81
4	112	8,231	91	449	94
5	91	8,222	91	441	92
6	60	8,490	94	460	96
7	47	9,029	100	477	100
8	29	8,755	97	462	97
9	25	8,718	97	476	100
10	11	8,887	98	464	97

From the above table it is found that a heifer that produces 6700 pounds of milk and 360 pounds butter fat as a two-year-old will yield 9000 pounds milk, and 480 pounds butter fat as a mature cow, at seven years of age. But she becomes over 90 per cent as efficient at four years old, or practically mature with the third

calf. And apparently the cow will hold her maximum efficiency through her tenth year.

We find also from this table that young cows gain an easier entrance into the Register of Merit than old cows, and the same is true with all dairy breeds. To prove this statement we will call attention to the fact that six-year-old cows exceed two-year-old cows by 101 pounds fat, or by 23 per cent, while the standard for entrance into the official test book has a difference between these ages of 110 pounds (250 pounds for two year-olds and 360 for five years and over) or 30 per cent. To state it differently a two-year-old excels her requirement by 30 per cent, and the six-year-old one excels hers by only 22 per cent. But the error is not a serious one.

A METHOD FOR DETERMINING LIME IN DAIRY PRODUCTS

T. MOJONNIER

Research Laboratory, Mojonnier Brothers Company, Chicago, Illinois

In the course of studies upon the lime content of milk, it was found very desirable to have a simple and accurate method for making this determination. The following method was devised to fill this want.

DESCRIPTION OF METHOD

Two variations of the method are possible:

(1) Measure or preferably weigh the samples into clean Babcock test bottles. In all cases except when testing whole milk, add to the bottle sufficient distilled water to bring the total weight up to 18 grams. Mix samples with the water in the bottle very thoroughly. Now add slowly with constant shaking about 15 grams C. P. sulphuric acid; centrifuge for about ten minutes. Add sufficient distilled water to float off the fat. Centrifuge until the last visible traces of fat are gone, adding additional water if this might be required. Pour the solution into a beaker, and wash out the bottle with three successive small portions of distilled water. Add two volumes of 95 per cent grain alcohol, and allow to stand over night. Filter, using preferably, a Gooch crucible with asbestos. Wash the precipitate by decantation, using grain alcohol. Dry thoroughly. Ignite at a moderate temperature, to a constant weight. If a filter paper is used, dry the precipitate in the filter and ignite together.

(2) Transfer to a beaker the residue remaining in a Mojonnier fat extraction flask at the end of a fat extraction. Neutralize the ammonia carefully with C. P. sulphuric acid. Add 10 cc. in

addition to that required for neutralizing. Add two volumes of 95 per cent grain alcohol, and allow to stand over night. Proceed as under (1).

SIZE OF SAMPLES RECOMMENDED

The size of sample to use can be varied with the method employed. Table 1 gives the amount recommended under the two methods. Slight variations will not effect the accuracy of the results.

TABLE 1

Weight of sample recommended

PRODUCT	BABCOCK METHOD	MOJONNIER METHOD
	grams	*grams*
Whole milk, skim milk, butter milk, and whey. . . .	18	10
Evaporated milk, plain condensed whole and skim milk, ice cream mix, and cream	9	5
Milk chocolate, cheese, malted milk, whole and skim milk powder, and butter.		1

EXPERIMENTAL EVIDENCE UPON THE ACCURACY OF THE METHOD

Ten grams of gypsum were heated to red heat. Weighed samples of this were ignited with filter paper, and found upon re-weighing to have undergone no change in weight.

In another experiment a sample of gypsum was treated with sulphuric acid diluted 1–5, decanted, filtered, washed, dried in electric vacuum oven, and ignited to constant weight. To about 0.1000 gram portions of this ignited product was now added 17 cc. of distilled water; 17 cc. of C. P. sulphuric acid, and after cooling, 100 cc. of 95 per cent alcohol. After standing over night, the precipitate was filtered, dried, ignited and weighed. The samples showed no loss in weight.

RESULTS OBTAINED BY THE ABOVE METHOD

The results obtained by means of the above method in the case of different dairy products are given in table 2.

The method does not apply in the case of sweetened condensed milk or other products containing large amounts of sugar, on account of the solubility of calcium sulphate in sucrose solutions.

TABLE 2

Lime content of dairy products as found by above method

TEST NUMBER	PRODUCT	PER CENT CALCIUM OXIDE		OPERATOR
		Original	Duplicate	
1	Whole milk	0.122	0 136	Author
2	Evaporated milk	0 284	0.276	Author
3	Evaporated milk	0 306	0 302	Author
4	Evaporated milk	0 344	0.340	Author
5	Evaporated milk	0.364	0.361	Author
6	Evaporated milk	0.288	0.289	Author
7	Evaporated milk	0.357	0 354	Prof. H. C. Troy
8	Evaporated milk	0 371	0.364	Prof. H. C. Troy
9	Whole milk	0.141	0 141	Prof. H. C. Troy
10	Powdered skim milk	1.410	1.420	Prof. H. C. Troy
11	Butter milk	0.159	0.156	H. J. Liedel
12	Ice cream mix	0.195	0.188	H. J. Liedel
13	Cheese		0.969	H. J. Liedel

CONCLUSIONS

The method described can be used to determine the lime content of all dairy products excepting those containing large amounts of sucrose. It is simple and accurate.

OPEN FORUM

The Biggest Problem Confronting Our Dairy Industry: Can the American Dairy Science Association Offer a Solution for It?

I do not hesitate to say that the biggest problem confronting the dairy industry is the improvement of the quality of our dairy products, especially our butter and cheese. Nor is there any doubt in my mind that the American Dairy Science Association can offer a solution for this problem if its members will put their best thoughts on the problem and devote their best efforts to its solution. There can be no doubt, for who should be better able to find a solution for this problem than those members of this Association who are daily dealing with the research, commercial and economic aspects of the dairy industry?

Considering the problem analytically from the standpoint of the fundamental, psychological and economical principles involved in its solution, we must agree that it can be solved in part if not in its entirety.

THE FIRST FUNDAMENTAL PRINCIPLE

The first fundamental principle involved is economic and has to do with the producer. If he is to be expected to produce a better quality of milk or cream from which a higher quality product can be made, he must be offered an incentive to do so and he must be rewarded for doing so. Economic results are determined by economic conditions. Is there a demand at the present time for a larger quantity of butter and cheese of higher quality than is now produced? If this demand was filled, could sufficient price be obtined for the additional quantities of high quality product so that the farmer would be rewarded for his part in helping to produce it? These questions must be answered in the affirmative, else there can be no possible incentive offered the farmer, and without an incentive to do better, to produce better, very little progress or improvement can be expected.

Our nation today is the creditor nation of the world, and our purchasing power is larger than that of any other nation. We should have here the best market in the world for dairy products and especially

dairy products of high quality, for only consumers of high purchasing ability are able to buy high quality dairy products. If we do not produce these products of high quality, then limited supplies will make for high prices for such products, unless foreign dairy countries send their high quality products here to supply this demand. Surely we can afford to produce and supply our own markets with these high quality products if other countries can do so. If we can't, then we must expect to obtain our food stuffs largely from foreign lands, because, when dairying as a business fails and is unprofitable in this country, then many other lines of agricultural production will also fail; for what phase of agriculture can be made more profitable than dairying when it is efficiently conducted? Our dairy industry must always compete as a business with every other kind of farming suited to dairy sections, and the dairy industries of all foreign countries must do likewise. We are told we should consume twice the dairy products we are now consuming, that proper national advertising should sell this additional amount of dairy products when we produce the quality product, sell it on a quality basis and tell the consumer why he should buy twice the amount he is now buying.

A SECOND FUNDAMENTAL PRINCIPLE

Confidence is the basis of most business dealings. If you have little confidence in the business methods of a person, you are not inclined to increase or enjoy your business dealings with that person. Business dealings are mostly prompted by a mutual benefit to be derived and a certain amount of personal satisfaction which can hardly be classed as mutual benefit. It is regarded generally that the nearer the business dealings can be placed on a fair and equitable basis, the greater the personal satisfaction obtaned and the farther the mutual business relations will be extended. In fact, confidence is promoted by fair and equitable business dealings.

A BASIS FOR EQUITABLE DEALING IN DAIRY PRODUCTS

The most equitable basis for dealing in dairy products is that of quality—that is, the producer's product would be paid for on a basis of quality and the products should be sold to the consumer on a similar basis. Grades and standards for quality are essential for such equitable buying and selling methods. Today, such do not exist, or if they exist they are not used as they should be; therefore, a great weakness exists in our present dairy marketing system and a serious handicap is placed

upon improvement in the quality of our product, and upon increased consumption of our products.

Standards of quality must be established and our products must be marketed upon a quality basis, for it is fundamental to fair and equitable dealing in dairy products and to progress in our industry.

CREAM QUALITY AND BUTTER QUALITY MUST BE CORRELATED IN THE STANDARDS AND GRADES OF EACH

If cream is bought on a quality basis, the grades or various standards of quality for cream should be directly correlated to the grades or standards of quality of the butter resulting from the various grades of cream. Can such be established? That remains to be determined. Here is a problem for the practical butter makers and cream graders to study, as well as for the research investigator. A first and necessary step in such a study is a definitely established standard for the various scores or grades of butter, as has been worked out by the Dairy Section of the Bureau of Markets of the United States Department of Agriculture and which is fully described in Service and Regulatory Announcements No. 51, entitled "Rules and Regulations for the Inspection of Butter Under the Food Products Inspection Law." Copy of this bulletin may be secured upon request of the United States Department of Agriculture. With this standard clearly in mind, careful and thorough studies should be made of the quality of cream require to produce these grades or qualities of butter, and especially of the various factors or characteristics of the cream, their degree of variation and the effect of these degrees on the quality of the resulting butter.

TENTATIVE GRADES OF CREAM

The following is a tentative basis for establishing grades for cream, in which a correlation is sought in the grades of cream of certain scores and the grades or scores of butter resulting from the churning of the various grades of cream. These grades are merely suggestive of what ultimately should be produced. They are not the result of any definite laboratory experiments or investigations such as are necessary for the proper correlation of cream and butter quality with definite correlated standards of quality for each.

Tentative grades for cream

Ratings for each factor considered

Flavor	45
Acidity	25
Body	10
Richness	10
Foreign material and container	10
Total	100

GRADES	FLAVOR, 45	ACIDITY, 25	BODY, 10	RICHNESS, 10	FOREIGN MATERIAL AND CONTAINER, 10
Grade 1-A 94 or above	Very clean and pleasing	Sweet	Perfect	Above 18 per cent fat	Perfect
Grade 1 Above 92.	Clean and pleasing	Under .30	Smooth	30 per cent fat	None and clean and sanitary
Grade 2 90 to 92...	Fairly clean yet palatable	Under .45	Smooth	25 per cent fat	None and clean and sanitary
Grade 3 88 to 90 .	Slightly objectionable	Under .60	Slightly defective	20 per cent or above	Slight foreign material and unsanitary container
Grade 4 83 to 88...	Strongly off flavor	Over .60	Very defective	18 per cent fat or above	Noticeable effect of either or both foreign material and unsanitary container
Grade 5 Below 83..	Foul and wholly undesirable				Excessive foreign or very unsanitary container

The above outline is wholly tentative and is intended to suggest merely a possible basis for study. The use and application of such a basis of grading in practical commercial work would necessarily have to be established and governed by carefully worked out rules and regulations in which the number of points to be cut for defects would be clearly established for each defect. Such rules and regulations can not be arbitrarily established. They must be determined by careful investigation and due consideration to all economic factors involved, especially from the standpoint of relation of defect in cream to market grade of resulting butter and market value of it.

THE USE OF STANDARD GRADES OF CREAM BY CREAMERIES

Presupposing that creameries graded their butter and so handled it that the grade or quality of it was known, possibly branding it on the package, and it was sold to the consumer on a quality basis of 87 score, 89 score, or 93 score, what would be the result if the creamery bought cream from producers on a corresponding quality basis? If each of the four grades of cream purchased were churned separately, it would be a simple matter. Each grade of cream would be paid for according to the market value of the resulting quality of butter. And this would be but logical and would promote fair and equitable business dealing with the farmers. The spread in price between the grades would be determined by economic conditions and not on an arbitrary basis which might be quite unfair and unreasonable, therefore unsatisfactory. The use of a quality basis in buying cream would offer an incentive to the producer of low quality and provide a reward to the producer of high quality cream. It would establish a basis for fair dealing and beget confidence in buyer and seller. On such a basis of dealing, mutual benefit to buyer and seller would be fairly assured.

If, however, all four grades of cream were churned together what would be the result? Would it be practically identical with the churning of each grade separately if the price paid for each grade of cream were based on the market value of the resulting quality of butter made from each grade? An example will illustrate the possible practical working out of this proposition.

Assuming a creamery is able to pay the same price per pound for butter fat that it receives for butter and butter is quoted as follow: 87 score 37 cents; 89 score 40 cents; 91 score 42 cents; 93 score 43 cents, and that a creamery receives 100 pounds butter fat in 87 score cream, 200 pounds butter fat in 89 score cream, 200 pounds butter fat in 91 score cream and 300 pounds butter fat in 93 score cream, it would then pay for the cream the following prices:

100 pounds butter fat, 87 score cream at 37 cents..............	$37.00
200 pounds butter fat, 89 score cream at 40 cents..............	80.00
200 pounds butter fat, 91 score cream at 42 cents..............	84.00
300 pounds butter fat, 93 score cream at 43 cents..............	129.00
800 pounds butter fat bought for..............................	$330.00

Average cost per pound butter fat, 41¼ cents. Allowing 20 per cent overrun, there would be produced 960 pounds of butter which should have an average sorce of 90.75, established as follows:

100 × 87	8,700
200 × 89	17,800
200 × 91	18,200
300 × 93	27,900
800	72,600

960 pounds butter of	90.75	Score
960 pounds butter scoring 90.75 at 42 cents per pound		$393.20
Cost of 800 pounds butter fat		330.00
Difference		$63.20

Difference to cover cost of manufacture equals $63.20 or 6.6 cent per pound butter made. This is a purely theoretical case and it would be interesting to know how it would work out in practice. Who can say that it could not be worked out? If it could not, could a practical basis of grading cream be established and a practical method of applying such a basis to the buying of cream be worked out?

Here is a big problem, to the solution of which the members of the Dairy Products Section of the American Dairy Science Association can well afford to give their best thought and effort, for upon its solution is dependent the future quality of American creamery butter.

Roy C. Potts,
Bureau of Markets, United States Department of Agriculture, Washington D. C.

REVIEW OF DAIRY LITERATURE

A New French Dairy Journal

Le Lait is the name of a new French journal relating to the dairy industry. It is published at No. 2 Quai Chauveau, Lyon, France. Prof. Chas. Porcher, a distinguished author and investigator, is the editor-in-chief, and he is assisted by a corps of collaborators from various parts of Europe. The subscription price is 35 francs per year. The plan of the publishers is to issue not less than ten numbers per volume, one volume to appear each year.

The aim of the editors is principally twofold. First, to use *Le Lait* as a medium for the dissemination of knowledge of the dairy industry from numerous view points including both scientific and practical problems, covering a wide range of subjects. From this standpoint, it will prove of worldwide interest and it should find readers wherever the dairy cow is kept. Second to use *Le Lait* as an organ for encouraging the development of the dairy industry in France, and also the use of more milk and milk products among the French people, all of which are most worthy aims.

The high quality of the first number gives good promise that it will in the future reach the mark set for it by its publishers. The dairy industry, the world over owes a great debt to France. The discoveries of Pasteur practically applied in the so-called pasteurization of milk have made his name a household word especially in the United States. The homogenizer is another French invention that has brought great benefit to the dairy industry. *Le Lait* is destined to increase our debt still more. It is hoped therefore that the latter will receive from the United States such moral and financial support as may help to insure its success.

T. Mojonnier.

CREAMERY INSPECTION DATA

H. W. REDFIELD AND W. A. STOCKING

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

During the summers of 1918 and 1919, the authors jointly or separately visited approximately 150 creameries situated in the following states: Alabama, Arizona, California, Colorado, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, and Wyoming. Of these creameries, each of 70 manufactured 500,000 or more pounds of butter per year. Eighty of them manufactured respectively less than 500,000 pounds of butter per year. The total output of the entire group of creameries as reported by their managers was approximately 200,000,000 pounds of butter.

In each plant visited, the information recorded was combined from the word of the managers, from the records of the creamery, and from direct observation. The information sought included the total amount of cream received, and the percentages of this total obtained from shipping stations, from single shippers, by cream routes, and by delivery by the patron directly. Where cream was shipped, the range of distance covered by such shipments was approximated. Concerning the stock itself, the range of fat content, acidity, and basis of grading, if any, were recorded. With reference to methods of manufacture, the use and type of neutralizer, if any, and the methods of application were observed. The method, temperature, and time of pasteurization were recorded. The character and percentage of starter used were noted. Details of churning, when obtainable, were described. Concerning the resulting product, the factory grading, the percentage represented in each grade and the amount of salt used were tabulated, and finally the score of the different grades of butter manufactured and the methods of marketing were discussed with the management of each creamery.

Although the number of creameries visited is not great, care was taken to make the inspection cover as representative a series as possible. It is believed that a summary of the observations made in the course of this investigation may be of considerable interest. A very large number of investigators have discussed the problem of butter manufacture. No attempt will be made to review this extensive literature. For such discussions, the reader is referred to standard dairy references and the college and experiment station literature. Such investigations cover specific methods of manufacture, the applications of pasteurization to the production of a butter which will maintain its character in storage, the cause and nature of particular defects in the product.

In this investigation, which is the first of a series of studies upon the problem of butter, the authors endeavored to obtain enough observations upon the practical problems of production of cream, under the most varied conditions, of method of delivery, of the condition of the cream when received, of the methods of manufacture in the creamery, to aid in interpreting a series of intensive studies to be made by ourselves and others of experimental work in the creamery. This paper will be limited to a summary of the observations made in the field inspection of the creameries themselves.

SANITARY CONDITION OF PLANTS

The sanitary condition of the creameries was very satisfactory. This is true of the plants of all sizes, from the very smallest up to the very largest centralizing establishments. There were a few exceptions to this condition but such exceptions are to be anticipated among manufacturing establishments. The principles of sanitation as applied to creameries are so well worked out and so well known that failures of this kind are local and personal matters which should be looked after by boards of health.

EQUIPMENT OF PLANTS

On the whole the plants were efficiently equipped. In many, especially small ones, the equipment was not expensive, but in

practically every case the machinery was sufficient for doing satisfactory work and was of modern construction. Occasionally the equipment was somewhat out of date and badly worn. In some, especially of the larger plants, the equipment was of the most modern type and occasionally quite expensive.

It is noteworthy that the equipment in both large and small plants with few exceptions includes pasteurizing machinery of such type as to obtain satisfactory results. There are, of course, a series of small creameries, in particular sections of the country, in which pasteurization apparatus is inadequate or not present at all. It is clear, however, that the cost of adequate pasteurizing machinery does not interfere with its introduction in any successfully managed plant.

As a rule little criticism can be made from the standpoint of equipment. It is thus clear that dairy machinery as installed in the ordinary creamery is of such character as to admit of successful operation.

METHODS OF MANUFACTURE

The methods of butter manufacture observed throughout the territory visited are surprisingly uniform. It is evident, that the butter industry has become so well standardized that there is little difference in the essentials of manufacture in various parts of the country. Minor differences in detail of procedure in different sections of the country do occur. In individual plants in any locality such differences are occasionally found but these are, as a rule, unimportant in character.

So far then as the plants visited are representative of the butter industry, creamery butter is rapidly coming to mean butter made from pasteurized cream. Both large and small plants are using such apparatus successfully. Both flash and holding methods are in common use. The holding method seems to be more common in the smaller plant where the volume of cream handled is not very large. The temperatures and time of exposure vary in different plants. In holding pasteurization 145° F. for twenty to thirty minutes is most common. Occasionally

165°F. for ten or twenty minutes is used. Where the flash method was used, the temperature was varied from 165°F. to 185°F. In the larger plants there is the decided tendency to use the double flash method, in which the cream is heated to a moderate temperature as it passes through the first machine, and then goes directly to the second one where the desired temperature is obtained. In those large plants in which a grading of cream is practiced, there is a distinct tendency to pasteurize first grade cream at a considerably lower temperature than second grade cream. Such temperatures as 185°F., especially when accompanied by the use of a retarder, are closely associated with conditions in which poor cream or second grade cream becomes a prominent characteristic of the raw material.

There appears to be a decided tendency to discontinue the use of cream starters in all parts of the country. Two chief reasons were given for the discontinuance of this practice. In some places it is difficult to secure satisfactory material for making starters but the chief reason given is that the experience of recent years has proved that butter made from cream with low acidity keeps in storage better than that made from cream of high acidity. For this reason, primarily, most of the butter manufacturers are churning cream with as low acidity as possible. This, of course, eliminates the use of the starter. In those plants where the cream supply is received sour, the practice of reducing the acidity with alkalies is generally followed. The amount of alkali used depends upon the degree of acidity of the cream supply. In some sections of the country reduction of acidity is accomplished by the use of lime or lime water. In some sections soda is used. Some use milk of magnesia. In many plants a combination of two of these agents is employed. Occasionally cleansing powder was found in use. In most plants, especially of the larger ones, the percentages of moisture and salt in the finished product are very carefully watched and controlled, so that the finished product is a very uniform one from day to day in a given plant and also in different plants of an organization. The large volume of unsalted butter reported by these creameries is also noteworthy.

AGE OF CREAM

In respect to age of cream, there are marked differences in the different sections of the country. In those sections where sweet cream is delivered to the creamery, it is usually not more than one or two days old. In the sections where the creameries receive sour cream, it is practically always older. Probably a very large percentage of it during the summer time is from four to six days old upon arrival at the creamery. A small proportion is older, occasionally as much as seven or eight days of age when received. Sometimes shipments older than this are accepted. There is a tendency on the part of plant operators to urge the farmers to deliver as frequently as possible. It was not, however, the practice of the creameries or cream buying stations to refuse simply because of its age in days.

QUALITY OF CREAM

Sweet cream. In general the sweet cream was of good quality. In some cases, especially in the South, milk and cream at certain seasons became badly tainted from certain types of vegetation in the pastures. Feedy flavors were also reported in various parts of northern Michigan. Aside from the instances in which the feed was regarded as responsible, the sweet cream was usually satisfactory. In certain localities, notably northern Iowa, the smaller creameries in Arizona, and certain sections of California, sweet cream alone is received. Most of these plants receive their supplies from a relatively small area per plant. The exceptions to this are sufficiently noteworthy, however, to indicate that the number of these plants could be very greatly increased with resulting economy of operation and improvement of the butter supply as a whole.

Sour cream. The acidity of the cream varied considerably in the plants visited. Occasionally, cream was found only mildly acid, 0.2 to 0.3 per cent. In other sections, the acidity ran much higher. Extreme cases were found where the acidity tested 1.5 per cent. A rough average for sour cream might be 0.5 per cent. It is noteworthy that some of the sourest cream was

observed in the central states. The regions tributary to St. Louis, Kansas City, Omaha, Lincoln, Oklahoma City and Denver, showed a larger percentage of exceedingly sour cream than areas in the far South where temperatures are much higher. Neither climatic conditions nor the state of farming is sufficient to account for so much sour cream in some of these areas. In the South, notably Mississippi, where dairying has developed rapidly during the last few years, special attention has been given to the care of cream so that it reaches the plant with lower acidity than in many regions in which more might be expected because of more favorable climate. In Arizona where the climate is extremely hot but where the development of the butter industry has also been recent, cream was found delivered at the plant one or two days old but relatively low in acid. The same was equally true in the San Joaquin Valley of California, where the cream supply comes from comparatively short distances.

Much sour cream has a clean, sour flavor. Some part of it constantly shows various types of "off flavors." These are designated by the butter makers by such names as yeasty, vinegary, cheesy, stale, bitter, onion, weedy, metallic. There is some difference of opinion as to which of these defects cause the most difficulty. Stale and yeasty creams were, however, most generally condemned as making most serious trouble from the standpoint of the score of the butter obtainable after manipulation. Some butter makers regarded metallic cream as most troublesome and in a very few cases weedy flavors were reported as the most serious difficulty. Since weedy flavors are only a local matter, the stale and yeasty cream may be regarded as that which interferes most widely with the score of the finished product.

METHODS OF CREAM DELIVERY

Aside from the local product delivered by the farmer, three general methods of cream delivery were observed in various parts of the country: A, direct shippers; B, receiving stations; C, cream routes.

Of these three, the first two methods of delivery were first developed in those sections where dairying was somewhat scattered and the local supplies too small for successful manufacturing. Both are now large factors in many dairy communities. Some companies adhere rigidly to the direct shipper system while others use both the direct shipper and the receiving station methods. In most cases the butter maker stated that the cream received from the direct shippers is normally of better quality than that coming from the shipping stations. The reason given was that the direct shipper is in closer touch with the central company and can be informed directly when his product is unsatisfactory. In such cases it becomes easily possible to discriminate in price in favor of the better grades of cream. When cream is received from shipping stations, the person in charge of the station may have little knowledge of the dairy business. Cream is tested for fat and paid for at the time of delivery, and consigned to the creamery by its own agent. The cream from different shippers is generally mixed before shipping to the central plant, so that the cream of the individual farmer has lost its identity. Further, the men in charge of receiving stations are frequently poor judges of quality and in many cases they receive their commission on the basis of the amount of butterfat purchased irrespective of the flavor of the cream. All of these factors work together to depreciate the value of shipping station cream. These stations, as far as observed, were properly equipped for making the Babcock test, were generally insufficiently equipped for washing and steaming cans, and not equipped at all for cooling the cream.

These observations are in harmony with the statements of others with reference to shipping stations. In certain sections the delivery by cream routes was observed. Where automobiles are used, these routes extend as far as 30 to 40 miles from the central plant. The truck is usually owned and operated by the creamery. Sometimes the cream is gathered daily. In other cases the collections are made on alternate days. This system appears to be quite satisfactory where roads permit the constant operation of delivery trucks.

GRADING CREAM

In a constantly increasing number of cases cream is purchased by grade and a differential of 2 to 5 cents per pound of butter fat is paid the producer of good quality product. In many cases, on the other hand, especially at shipping stations, one price is paid for all cream regardless of condition. A general desire has been expressed by creamery operators to follow some grading system and to pay on the basis of quality. Thus far grading has failed in many sections, because of competition between creameries for the cream. This appears to be especially true where several creameries have shipping stations in the same territory with managers paid for quantity not quality of shipments.

In the plants receiving sweet cream, one grade of butter only is made, since the cream accepted is all sufficiently good in quality to produce a high grade product. In the sour cream plants they usually sort the cream into two or three grades when received. The first grade includes all cream which the butter makers consider sufficiently good to go into their first-grade product, for which they have established a market. Throughout much of the territory visited, this product scores about 90 to 91. The No. 2 grade includes cream which is more stale, foamy, or yeasty, or has other off flavors which are too pronounced to allow inclusion in the so-called first-grade product. The practice of various creameries differs, but this grade commonly is made to include such cream as will make a butter scoring from 88 to 90 according to the factory.

Number 3 grade includes the most pronounced stale, yeasty, cheesy, weedy, or other off flavors. In many of the plants, no cream was reported as too poor for use. In others an occasional can was returned to the farmer or made into packing stock. The percentage of cream going into the different grades in the various creameries differs markedly. In some cases all but about two per cent went into first grade. In others as high as 30 per cent would be in second grade and 5 to 10 per cent in third grade. Most plants limit the grading to first and second, except perhaps during the two or three hottest months of the year.

The disagreement in grading practice observed probably accounts for great differences observed in creamery butter, since the amount of "off flavored" cream put into first grade at the factory depends upon the judgment of the butter maker or the instructions which he has received. With a standardized output at a particular market score, first grade is made to include all off-flavored cream which can enter without depressing the score of the butter below this particular point.

The importance of the introduction of this off-grade cream into first grades can hardly be overestimated. Observations in certain of these creameries have shown that sour cream in otherwise proper condition can be made into really high-grade butter, but the introduction of comparatively small percentages of off-flavored stock into so-called first grade lowers materially the general level of the product. When this product, as from the group of large plants in the Great Plains and Prairie regions, totals to hundreds of millions of pounds, that lowering of the general level has a very wide effect upon the industry as a whole.

While in theory, all parties recognize the desirability of grading, adequate steps toward the establishment of recognized grades have only recently been taken. With the approval of some dairy organizations, the dairy commissioner of Kansas and later the commissioners of Nebraska, Missouri, Oklahoma, and Colorado have promulgated a grading system. In their announcements the creamery is advised to include in first-grade product only cream which is medium or slightly sour but with a clean, acid taste, and sweet cream. All cream which is recognizably metallic, weedy, oily, cheesy, greasy, bitter, tainted, contains colostrum, is yeasty, stale or musty or very sour definitely goes into second or third grade according to the intensity of the off flavor. The terms used are those well known and in common use in the creamery industry and the desirability of such grading is quite generally recognized. The observations made indicate clearly that a comparatively small percentage of the total cream would be designated by any one or any combination of these particular off flavors. It is, therefore, clear that the low general level of the output of large numbers of

factories is fairly definitely due to the inclusion of materials in first grade which belong properly in second-grade butter or which should not be used at all for creamery butter.

The regions visited show a marked tendency toward a higher grade of butter in those plants in which a sweet cream is used. This applies to large plants as well as small plants. Butter from such plants normally scores from 2 to 4 points higher than that in those plants using sour cream. While these higher grades of butter were more commonly found in small plants drawing their supply from local territory, the occasional exception is noteworthy. Certain large plants, in which the collection of carefully produced cream is organized along proper lines, produce an equally high grade of product. Further, in many small plants the methods of operation are not as uniform and the product when finished is more variable than in the larger plants.

Under such conditions, small creameries produce some of the lowest grades of butter. The smaller plant with its smaller output is also at a disadvantage in shipping and selling its product. As a result butter of varying grade in small lots frequently commands a less satisfactory market than butter of very moderate quality but uniform from day to day and in large quantity. This disadvantage can only be offset by disposal of the product to local markets or by such grouping of plants as will give greater advantage in selling.

DISCUSSION AND SUMMARY OF OBSERVATIONS

1. The flavors which were especially criticised by the creamery men themselves as preventing the manufacture of better butter, named in the order of their importance, were yeasty, stale, bitter, metallic, unclean, weedy, cheesy, and vinegary cream.

2. Off-flavored cream was found in all sections visited, predominantly in such sections as permitted the delivery of cream from 4 to 6 days old. The causes of such flavors were not observed in this investigation, although dirty utensils have been many times reported by others.

3. Poor quality in butter is primarily due to poor quality in cream. This is almost invariably associated with failure to

grade properly. It is also associated with failure to pasteurize in a few of the factories.

4. Sour cream even with acidity up to 0.7 per cent, if free from taint, can be made into butter scoring 92 to 93, by the newer and better organized factories. Scores higher than this are reached regularly from cream of really high quality.

5. The factors leading toward improvement in quality in butter, as observed, were (1) Location of the factory as closely as possible to the supply of cream; (2) The collection of cream every day by means of cream routes or by direct delivery; and (3) Cooling the cream at all times before manufacture.

6. The quality of cream and the quality of butter made from it is not primarily dependent upon the size of the plant or the radius of its cream-producing territory but upon the intelligent care used in its production, upon the regularity and promptness of its delivery, and upon its proper grading and manufacture at the factory.

THE POSSIBILITY OF INCREASING MILK AND BUTTERFAT PRODUCTION BY THE ADMINISTRATION OF DRUGS. II

ANDREW C McCANDLISH AND T. M. OLSON

Dairy Husbandry Section, Iowa State College, Ames, Iowa.

The process of milk secretion is not yet fully understood and there is extreme difficulty in determining some of the factors which influence it. It is the belief of many that certain drugs have galactagogic powers and will increase not only the total yield of milk and butterfat but also the percentage of fat in milk. Work with laboratory animals has apparently demonstrated the galactapoietic powers of a few drugs and similar results are also reported in certain cases with the human subject. The use of galactagogues in commercial dairying would be out of the question but the study of the possibilities of their use with cows on official or semi-official test is of interest. Attempts have been made by men in charge of herds to use such materials with the special object of increasing the percentage of fat in milk and the purpose of the work reported here is to ascertain, if possible, the probable results of such attempts.

No attention will be given here to experimentation with mammals other than the cow, for the simple reason that though much valuable work has been done with these subjects the results need not necessarily be directly applicable to the cow as there may be certain generic differences in physiological activity. It is known that in some cases, especially with the human subject, variations in milk production can be brought about much more readily than in the case of the cow.

The possible ways by which drugs may influence the mammary gland are many and varied, and in order to better understand the action of any specific drug it is well to consider at least some of these possibilities:

1. The action of the drug may be directly on the protoplasm of the secretory cells, either stimulating or inhibiting the action of the cells.

2. The secretory nerve terminations in the mammary gland may be stimulated or depressed, thus resulting in either an increased or decreased secretion of milk.

3. The action of the heart may be influenced and produce an increase or decrease in the rate of circulation of the blood, thus altering the volume of blood and the amount of nutrients which would pass through the udder.

4. The general vasomotor influence of drugs, in increasing or decreasing the amount of blood passing through the udder, by a vasoconstriction of arterioles in other parts of the body or by dilatation of the arterioles in the mammary gland, is important.

5. The effects of drugs on the digestive system, through their influence on the activity of digestion and absorption, and ultimately the amount of nutrients available for milk and fat production, are worthy of consideration.

6. The action of drugs on organs indirectly associated with the mammary gland might influence milk and fat production.

As these actions may be brought about separately or in almost any combination and in varying degrees of intensity, it is seen that the problem of the influence of drugs on milk secretion is a complicated one and the fact that individual cows vary in degree of susceptibility to drug action increases the complexity.

The problem is here treated with the view of determining the possibility of influencing the production of healthy cows and more particularly the percentage of fat in the milk. In conducting this work the one or two day tests of the dairy cattle breed associations were kept in mind because it is only in such tests that there would be the greatest opportunity and temptation to use drugs, and it is also fairly well recognized that a slight increase in the percentage of fat in the milk might be maintained for a few days only by the use of drugs, and in addition continued drug administration would be more readily detected.

There is a long list of substances popularly reputed to have galactagogic effects—amongst these are the aromatics, fennel, anise, caraway, juniper berries, coriander, dill, pimpinella, calamus; the bitter stomachics, sulphur, the neutral salts, the antimony preparations, and many others—but distinction must

be made between the use of drugs based on a knowledge of their physiological action and the use of those indicated by empirical teachings. The popular milk powders are compounded largely from the constituents just stated.

RÉSUMÉ OF PREVIOUS WORK

Very little experimental data is available on the influence of drugs on the milk and fat production of dairy cows, and only those used in the work reported will be considered here.

Aloes. It was found by Lanzoni (3) that the fat percentage in cow's milk was decreased by the administration of aloes, while McCandlish (4) found that aloes decreased milk production 1 per cent and increased the percentage of fat 4 per cent and the total fat yield 3 per cent. Henderson (2) found a decrease in both milk and fat yield and an increased percentage of fat.

Castor oil. According to McCandlish (4) castor oil caused a decrease of 10 per cent in fat percentage and 11 per cent in the total fat yield.

Strychnine. It was reported by McCandlish (4) that a mixture containing nux vomica decreased the milk and fat yield but increased the fat percentage only slightly, though with one cow in two trials there was an appreciable increase in the percentage of fat accompanied by a marked decrease in milk yield. Henderson (2) obtained negative results with nux vomica.

Sodium cacodylate. No reports are available on the use of sodium cacodylate but Hays and Thomas (1) obtained negative results on using Fowler's solution of arsenic.

Results are obtainable from the references given on a few other drugs but they are not included here as the other drugs mentioned were not used in this work.

PHYSIOLOGICAL ACTION OF THE DRUGS USED

In this work the drugs used include castor oil, aloes, strychnine, sodium cacodylate, rhubarb, potassium iodide, urotropin and benzoic acid. These have been chosen in view of the fact that a knowledge of their physiological action would seem to

indicate some possibility of their either directly or indirectly influencing the mammary gland.

Castor oil. This is a bland, non-irritating fluid, and in itself is not a purgative. On passing into the intestine, however, it is saponified by the pancreatic juice, and the ricineolates formed from the ricineoleic acid liberated are irritant and cause purgation. In this way nutrients that might otherwise be utilized are carried off and a general depression is also produced.

Aloes. The action of aloes begins in the large intestine, a fact which accounts for its slow action, and its active stimulation of peristalsis in this part of the alimentary tract. The active principle of aloes, aloin, is responsible for the purging action. It is also very bitter and therefore excites the salivary and gastric but not the intestinal secretions. The end products of aloes absorbed from the large intestine are eliminated by the bowels, kidneys and mammary gland. Its elimination by the latter route may cause a looseness of the bowels of the suckling animal, if a sufficient amount of aloes has been given to the dam. It sometimes causes diuresis; induces reflex irritation of the female pelvic organs; is an emmenagogue and may be abortifacient.

Rhubarb. This is a stomachic and bitter tonic, and therefore increases the salivary and gastric secretions, improves digestion, stimulates the appetite, and the vascularity and movements of the stomach. Its activity is partially due to its solvent action on bile. Rhubarb contains a considerable amount of tannic acid, which acts as an astringent and, after the evacuation of the bowel, may cause constipation. The presence of chrysophanic acid in rhubarb sometimes gives a yellow tinge to the skin, urine, sweat, and milk.

Potassium iodide. This is an alterative and therefore exercises an influence upon the nutritional and metabolic processes of the body. It is absorbed and eliminated rapidly, escaping from the body in all excretions and secretions, but largely through the kidneys and salivary glands. Although the greater portion escapes within twenty-four hours after administration, some remains in the body, resulting in an accumulation, following the administration of successive large doses.

Strychnine. When strychnine is given in therapeutic doses, a stimulating action on the central nervous system, especially the spinal cord, is found. The sense of touch becomes more delicate, and excitability more marked. Larger doses cause twitching of the muscles, followed by tremors, and then convulsions, in which all the muscles of the body are involved. The proper functioning of the respiratory muscles are interfered with, resulting in deoxygenated blood. The heart action is slowed by the stimulation of the cardio-inhibitory center, and the vaso-motor center is stimulated, causing a constriction of the splanchnic vessels, deflecting the blood from the internal organs to the skin and limbs. A complete disorganization of the vaso-motor center follows an overdose. Strychnine increases the flow of saliva, stimulates the appetite, and increases the activities of digestion. It is absorbed mainly from the intestine.

Sodium cacodylate. This is less toxic than other arsenic compounds, due to the slow liberation of arsenious acid in the animal body. It is alterative, modifying nutrition. It stimulates the central nervous system, and induces vaso-dilatation of the capillaries. Sodium cacodylate is eliminated in the urine, feces, sweat, and milk.

Urotropin and benzoic acid. No direct action can be attributed to urotropin, but it liberates formaldehyde, which acts as an irritant and a disfectant. The liberation of formaldehyde is accelerated by the use of an acid. It is eliminated largely through the kidneys, although small quantities can be detected in other excretions and secretions of the body.

METHODS OF EXPERIMENTATION

The four cows used in this experiment were allowed to remain with the general herd and were milked twice each day by the same milker; a sample was taken from each milking for the determination of butterfat by the Babcock method.

Information concerning the animals used has been tabulated and where necessary it is calculated to November 16, 1919, the day on which the trial started.

The feeding of the cows was conducted along with that for the general herd and records of the feed consumed were obtained. The animals were watered twice daily in the barn during bad weather but otherwise outdoors when they were exercising.

The experiment may be divided into two large sections, as it was believed best in the middle of the work to rest the cows for ten days and alter their grain rations to some extent.

TABLE 1

Animals used

	cow 298	cow 323	cow 373	cow 398
Breed	Grade Guernsey	Grade Holstein	Grade Holstein	Grade Jersey
Age, years	4	$3\frac{1}{2}$	$2\frac{1}{2}$	2
Fresh, days	112	75	15	51
Previous lactations	2	1	0	0
Live weight, pounds	860	980	970	700

TABLE 2

Daily rations

	cow 298		cow 323		cow 373		cow 398	
	First section	Second section	First section	Second section	First section	Second section	First section	Second section
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Corn silage	30	30	35	35	30	30	25	30
Alfalfa hay	5	5	5	5	5	5	5	5
Cracked corn	2	2	1	2	1	2	2	2
Ground oats	4	1	3	2	4	4	2	2
Wheat bran	3	1	3	2	2	2	4	2
Oil meal O.P.	2	2	4	2	3	3	4	2

Throughout the experiment the rations consisted of corn silage, alfalfa hay and a grain mixture of cracked corn, ground oats, wheat bran, and old process linseed oil meal.

The length of the experimental period during which any drug was administered was always two days. The check periods were not all of the same length. The plan of the experiment called for an eight day check period before and following the administration of each drug, but the plan could not be adhered

to rigidly. However, the length of the check periods did not vary more than one day either way. The first check period began November 16, 1919, and the last check period ended February 19, 1920.

TABLE 3

Drug administration

DRUG	NUMBER OF COWS	COW NUMBER	DOSAGES AND METHODS OF ADMINISTRATION
Castor oil	4	293 323 373 398	One-half pint given in morning and 1 pint in the evening for two days, as a drench
Aloes and rhubarb	4	298 323 373 398	One bolus of aloes and 2 boli of rhubarb in the evening, and 2 boli of rhubarb in the morning for two days. Each bolus of aloes contained 1 ounce of aloes. The rhubarb bolus contained $\frac{2}{3}\frac{2}{2}$ ounce rhubarb
Potassium iodide	4	298 323 373 398	Cows 298 and 398 received 3 drams of potassium iodide in 1 quart of water evening and morning for two days. Cows 323 and 373 received 4 drams of potassium iodide in 1 quart of water evening and morning for two days
Strychnine	3	298 373 398	Cows 298 and 373 received hypodermically $\frac{1}{2}$ grain strychnine in the evening and $\frac{1}{4}$ grain in the morning for two days. Cow 398 received $\frac{1}{4}$ grain twice a day for two days
Sodium cacodylate	3	298 373 398	Twenty-four grains of sodium cacodylate in 20 cc. of distilled water twice a day for two days, given hypodermically
Urotropin and benzoic acid	3	298 373 398	Cow 298 received 2 drams urotropin in 1 quart of water twice a day for two days. Cows 373 and 398 received 2 drams of urotropin and 2 drams benzoic acid in 1 quart of water twice a day for two days

In order to obtain a reasonable idea as to the influence of the drug used, the average daily production of each cow during the check periods immediately preceeding and following the period

TABLE 4

Average daily yields of milk and fat

DRUG	PERIOD	COW 298			COW 323			COW 373			COW 398			AVERAGE		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs	*per cent*	*lbs*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
Castor oil	Check	14.1	4.85	0.68	10.1	4.14	0.42	24.7	3.70	0.91	16.0	5.16	0.82	16.2	4.38	0.71
	Experiment	14.3	4.27	0.61	10.0	3.51	0.35	25.3	3.51	0.90	15.9	4.43	0.70	16.4	3.92	0.64
Aloes and rhubarb	Check	12.5	4.73	0.59	9.6	3.73	0.36	25.5	3.55	0.91	16.1	4.89	0.79	15.9	4.15	0.66
	Experiment	12.3	4.99	0.61	8.3	4.44	0.37	25.1	3.76	0.90	16.2	5.27	0.85	15.5	4.49	0.69
Potassium iodide	Check	12.1	4.87	0.59	9.1	3.94	0.36	24.7	3.72	0.92	15.2	5.02	0.76	15.3	4.30	0.66
	Experiment	13.2	4.96	0.65	9.0	3.75	0.34	25.2	3.82	0.96	16.2	4.93	0.80	15.9	4.33	0.69
Strychnine	Check	12.2	4.55	0.56				22.4	3.82	0.85	15.1	4.99	0.75	16.6	4.35	0.72
	Experiment	11.9	4.91	0.58				24.0	3.72	0.89	15.6	5.09	0.79	17.2	4.41	0.76
Sodium cacodylate	Check	16.4	4.74	0.54				20.8	3.99	0.83	14.7	5.54	0.81	15.6	4.66	0.73
	Experiment	11.0	5.23	0.57				20.7	4.17	0.86	14.4	5.53	0.78	15.3	4.85	0.74
Urotropin and benzoic acid	Check	10.9	4.91	0.54				19.7	4.10	0.81	14.8	5.52	0.82	15.2	4.76	0.76
	Experiment	10.8	4.74	0.51				20.0	4.50	0.90	14.3	4.89	0.70	15.0	4.68	0.70

TABLE 5

Percentage change in production

DRUG	PERCENTAGE	COW 298			COW 323			COW 373			COW 398			AVERAGE		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs*	*per cent*	*lbs.*
Castor oil	Increase	1						2						1		
	Decrease		12	10	1	15	17		4	1	1	14	15		11	10
Aloes and rhubarb	Increase		5	3		19	3		6	3	1	8	8		8	5
	Decrease	2			14			2						3		
Potassium iodide	Increase	9	2	10				2	3	4	7		5	4	1	5
	Decrease				1	5	6					2				
Strychnine	Increase		8	4				7		5	3	2	5	4	1	6
	Decrease	2							3							
Sodium cacodylate	Increase		10	6					5	4					4	1
	Decrease	3									2		2	2		
Urotropin and benzoic acid	Increase							2	9	11						
	Decrease	1	3	6							3	11	15	1	2	3

of drug administration was obtained. This was used as a basis with which to compare the average daily production of the cow during the period of drug administration.

DISCUSSION OF RESULTS

Castor oil. The castor oil did not produce purging or even noticeable laxativeness in any case. There was a decrease in the percentage of fat and the total fat yielded in every case, and a slight increase in milk in two cases. The decreases in the percentage of fat and the total fat yield were 11 per cent and 10 per cent respectively, with a 1 per cent increase in milk yield. All the cows were thrown off feed, refusing to to eat all their grain for two feeds.

Aloes and rhubarb. The aloes and rhubarb produced an increase in each case in fat percentage and total fat yield, the average increase for the four cows being 8 per cent and 5 per cent respectively. A slight decrease occurred in milk production in three cases, the fourth showing an increase of 1 per cent. The marked increase in the percentage of fat in one case, that of cow 323, can be partially attributed to the fact that the cow went off feed on the administration of the aloes and rhubarb, and consequently, decreased greatly in milk production.

Potassium iodide. The administration of potassium iodide resulted in a variety of changes in the yield of milk, percentage of fat, and total yield of fat. One case resulted in a decrease in milk, fat percentage, and total fat. This cow was off feed, which may account for the decrease in her case, as in the other cases the tendency was upwards. An average increase of four per cent in milk yield, 1 per cent in percentage of fat, and 5 per cent in total fat yield, resulted from the administration of this drug.

Strychnine. The administration of strychnine resulted in a 2 per cent decrease in milk in the case of one cow, and a 3 per cent decrease in fat percentage in the case of one other cow. Aside from these decreases, an increase in milk, fat percentage, and butterfat yield followed the administration of strychnine. The average for the three cows was an increase of 4 per cent in

milk production, 6 per cent in total fat yield, and 1 per cent in the fat percentage. The animals manifested a slight nervousness, which can probably be attributed to the strychnine, but no other abnormal symptoms were noticeable. The fourth cow was eliminated at the beginning of the trial as she was difficult to keep on feed.

Sodium cacodylate. The sodium cacodylate was variable in its influences. In two cases there was an increase in fat percentage and total fat, with a 3 per cent decrease in milk in the case of one cow, and no change in milk yield with the other. In the third case there was a 2 per cent decrease in milk and fat, with no variation in fat percentage. The average for the three cows was a 2 per cent decrease in milk, a 4 per cent increase in fat percentage, and a 1 per cent increase in total fat yield.

Urotropin and benzoic acid. Urotropin was administered to one cow, while the two others were given benzoic acid and urotropin. The urotropin was administered alone to note whether the milk would indicate the presence of formaldehyde, without the use of an acid. A chemical examination indicated a positive test for formaldehyde, without the administration of an acid. Urotropin produced a decrease in milk, fat percentage, and total fat in the case of one cow, and when the benzoic acid was added the same results were obtained in the case of the second cow. In the case of the third cow, given urotropin and benzoic acid, an increase in milk, fat percentage, and total fat resulted. The average for the three cows showed a slight decrease throughout, though the individual variations, especially in the percentage and yield of fat, had been very wide.

SUMMARY

1. The great variations in the results obtained with different cows show that drug administration can not be relied on to favorably influence the yield of milk or butterfat.

2. The only result of much significance obtained was the marked decrease in fat yield and percentage of fat induced by the castor oil.

3. The aloes-rhubarb mixture was the only material administered which produced an increase in fat percentage with every cow. The high average increase obtained here, however, is probably due to the fact that one cow went off feed and decreased greatly in milk production.

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NECESSARY RECORDS IN MILK COST ACCOUNTING[1]

OSCAR ERF

Ohio State University, Columbus, Ohio

DIRECTIONS AND EXPLANATIONS

In securing costs it must be remembered that the figures are of no value unless they represent complete costs. The omission of part of the items or failure to charge them correctly renders the account valueless.

In figuring costs of the dairy, the accounts should be divided into three groups: (1) The bull account; (2) the young stock account; and (3) the producing herd account.

The bull account is finally charged to the young stock account. For illustration: It costs $125 to keep a herd sire for one year. If there are twenty calves then each calf will cost $6.25. This will check off the bull account and place it in the young stock account, which in turn is finally transferred to the producing herd account. For illustration: Add to the cost of $6.25 for service, a cost of $106 for feed, labor and other costs for two years and we have $112.25 which represents the total cost of the calf. The heifer is now charged as a cow to the producing herd at $112.25, thus wiping out the young stock account so that all of expenses are finally carried by the producing herd.

COST ACCOUNT OF THE PRODUCING HERD

This account embraces all cows that have freshened in addition to the dry cows, but does not include heifers or other cows not used for milk production.

This account if not taken according to the individual cow's time should be prorated according to the number of cows in the herd.

[1] This report on records in cost accounting was given by Professor Oscar Erf before the Products Section of the American Dairy Science Association, October 11, 1920.—EDITOR.

In case labor is included in any of the items, such as throwing down hay for the entire herd, a proportional share of the time should be charged to the producing herd. Example: If fifteen minutes are required to throw down hay for the entire herd and one-third is used for the young stock and the bull, then ten minutes of this time should be charged to the producing herd.

In figuring costs transportation from the farm to the shipping point of destination, should not be included in the producing herd account. Milk should always be figured on the basis of cost at the farm.

The cost account is divided into two divisions: (1) The Earnings, (2) The Expenses.

The earnings are grouped under three heads: (1) Milk, (2) Calves, (3) Manure.

The earnings are determined by weighing the milk of the individual cow; estimating the value of the calf at four days of age, or at its actual sale value if sold; and estimating the value of the manure.

The expenses are grouped under three heads: (1) Feed, (2) Labor, (3) Overhead or Other Costs.

The expenses are determined by adding the cost of feed, labor and overhead or other costs.

EXPENSES

(1) Feed

1. Feeds fed to stock should be priced at the purchase price laid down in the bin at the farm. This includes the cost of the feed plus the unloading and hauling charges and the interest on the investment. Or, if the feed is purchased, it should be valued at the farm sale value (meaning market value less cost of marketing, transportation, storage and collection charges) computed when fed.

2. Feeds having no sale value are to be figured on the cost of production.

3. Silage is valued on the value of standing corn, plus the cost of siloing, plus the interest upon the silo, wear and tear, and depreciation.

4. Permanent pasture should be charged in accordance with the principal used in determining land charges, or it may be replaced value of the average price of farm feeds to produce a similar quantity of milk and butterfat.

5. Crops that are continually harvested and have a sale value should be charged against the livestock at the farm value less the cost of harvesting.

6. Interplanted crops which cannot be harvested should when pastured be charged at the cost of production unless they have a local sale value as pasture.

7. Crops grown primarily for harvesting but pastured incidentally should be charged either at the local rate for such pasture or at the value less the cost of harvesting or any reduction in the yield due to grazing or the value of feed replaced by pasture. If the grazing results in no apparent reduction of yield and there is no local sale price for such pasture, the charge should be that of other feeds replaced.

8. Crop residue and crop waste left in the field should be charged at the local farm value. If no such value exists charge should be the value of other feeds replaced. The same rule should apply to crops grown for greater maturity but grazed incidentally.

(2) Labor

Any self respecting farmer should include in the costs of production the proper number of hours required to do the work and should charge it at the current price per hour. If the producer charges his labor at 20 cents an hour when the current price is 30 cents an hour, he is rendering his account valueless.

1. *Milking.* This includes the time required for driving the cows from the paddock or yard near the barn, into the barn; stanchioning them and tying them; getting the utensils such as milk pails, cans, etc.; rinsing them preparatory to milking; cleaning the cows at milking time; washing the udder; spraying for flies; milking the cows; releasing them from the stanchions after milking and taking the milk from the cooler.

2. *Milking machines.* When milking machines are used, in addition to the items listed in the paragraph above are the prepa-

ration of the milking machine; starting of the gasoline engine or motor; oiling the engine; and rinsing the machine before and after milking.

3. *Daily hours for feeding.* This includes the time required in taking the hay from the mow or from the stack; gathering soiling crops daily from the field and any feeds which have no market value; grinding the hay or shredding the stalks; and preparing feed in any manner at the time of feeding. If stalks are gathered from the field, shredded or cut and put in the barn at one operation, the labor should be charged to the value of the stalk. This also includes removing the silage from the silo and feeding it to the cow; and in case it is mixed with the grain, the time required to mix it.

4. *Mixing and feeding grain.* This includes the time required to take grain from the bins or cribs, shelling or grinding, soaking or in any manner preparing these grains and feeding them. It also includes mixing, salting, condiments, etc. If the grain is ground at the mill, the grinding should be charged to the price of the grain, as should also the proportional time for hauling grain to and from the mill and putting it back into the bin. Purchased grains are charged at cost price at the times the bags are emptied or the grain is in the bin. The labor of hauling the grain from the place of purchase should be charged to the cost of the feed, but time required for mixing and feeding is charged under this item.

5. *Watering cows.* This includes the time required to drive cows to and from the watering place when necessary; labor required to pump water or time to care for and start engines for pumping purposes; time to start heaters and care for them; cleaning troughs or water devices, etc.

6. *Driving cows to and from pasture.* This includes getting the cows from the pasture and driving them into a paddock or open court near the barn, and driving them back to the pasture.

7. *Cleaning stables, bedding and currying cows.* Cleaning stables has reference to the daily cleaning and delivering the manure to the pit, wagon, spreader, or depositing in a convenient place where it can be hauled to the field; sweeping stables or

feed alleys; sweeping down cobwebs and cleaning the walls; whitewashing or disinfecting the stable; cleaning out the gutters or drains; hauling and distributing bedding; currying, cleaning, clipping, disinfecting and grooming cows; cleaning yards or paddocks; and spreading straw in the yards.

8. *Washing utensils and care of milk.* This includes assembling and preparation of the cooler wherever necessary or assembling and preparation of the cream separator; time for pumping water; care and starting of engines, motors and pumps for cooling milk and pumping water; taking ice from the ice house and icing milk; rinsing the cooler or separator; cooling the milk; stopping engine; dissembling and washing cooler or separator; starting fires to heat water for washing utensils; and temporary repairing of utensils. In case a milking machine is used it is rinsed in the stable and time should be included for oiling the machine, washing, scalding and disinfecting it.

9. *Hitching up horses and hauling milk.* This includes the time required to hitch up a horse; prepare wagon or truck; loading and unloading of milk; time for hauling to the nearest station; unhitching the horse; unloading the empty cans; and proper preparation of cans and can covers or insulators, used for hauling the milk.

10. *Miscellaneous items.* This includes the time for taking care of sick cows as at the time of calving; milking them until the time when the milk is fit for consumption; greasing and massaging the udder, as in case of gargot, abortion or milk fever; preparing them for service and driving them to and from the breeding pen.

11. *Superintendence and clerical.* This includes time necessary to buy feeds; buy and sell cows to supply the dairy; buy and install equipment; repair equipment; clerical work; marketing milk; figuring rations; attending meetings; correspondence; accounting; and all superintendence and clerical work necessary to the dairy.

12. *Unproductive labor.* This includes all waste labor which is necessary in the operation of milk production, such as loss of time due to weather conditions; time lost due to breakage; unavoidable delay, etc.

13. *Horse labor.* This includes the actual labor of horses used for bringing the feed into the stable, or in some instances hauling soiling crops from the field. When a horse is used for hauling a large amount of feed from the elevator for instance, this should be charged to the cost of the field. This is also true when hay is brought in from the farm and put into the mow in large quantities during haying time. But if the hay stack is located in the field and daily supply brought in to the cows, then the cost of horse labor must be charged. If hay or other roughage is purchased off from the farm, then the cost of horse labor must be charged to the cost of the feed and the value of the feed will be the price paid for it, plus the cost of hauling. Time required for horse labor in delivering milk or gathering the cans daily, or in case of cream production, for delivering the cream, is included in this item. If delivery is done by automobile, then a charge should be made on the basis of commercial rates for hauling, as determined by current prices in the community. Any labor, such as driving to and from towns for emergency, such as medicines, repairs, etc., included under this item.

14. *Transportation expenses.* This includes all expenses incurred in operating trucks, automobiles, etc., for purposes explained under horse labor.

(2) Other Costs

1. *Inventories.* The first item under other costs is inventories and this is divided into buildings chargeable to the dairy; equipment chargeable to the dairy; and dairy cattle. The inventory is estimated at the beginning and at the end of the year. The valuation should be placed on the total buildings and equipment and due allowance made for the non-producing portion of the herd. Rise in price of material in buildings and equipment should be taken into consideration and should be prorated on the producing herd. The depreciation must be determined according to the inventory and extreme market prices cannot be taken into consideration, but must be set aside in a separate account. For illustration: A man values his cattle at $150 each, but at the end of the year due to sudden increase in value

of cattle, he sells a number of them for $300 each and values the remainder at the same amount. A substantial increase may be made on the old inventory; however, a sudden rise must be charged to the profit and loss account. The same is true when there is a sudden reduction in price.

2. *Current expense.* This includes all expenses in the care of the producing herd and whenever it involves other cattle or horses, a proportional share is charged to the producing herd.

3. *Cost of repairs.* This includes all nominal repairs but not extensive repairs, as when the wind takes the roof from the barn. Under such conditions an insurance rate should be charged and repairs should be made from the fund set aside for insurance. If no insurance has been provided then the entire cost of repair must be charged to that year's milk, but there is injustice in this method in that it shows an abnormally high cost for that particular year. An insurance rate should be charged on all items possible.

4. *Cost of repairs on equipment.* The same principal holds true in the case of equipment as with repairs on buildings. All extensive repairs on equipment should be charged to insurance.

5. *Insurance.* This should include insurance against fire and storms on all buildings. Insurance on equipment should include accident insurance. Insurance on cows should include insurance against death and benefit insurance as well. That is, if a cow loses a quarter her value is greatly reduced and the amount of depreciation should be covered by insurance. Insurance should be carried against contagious abortion and other diseases. The State provides a special insurance against tuberculosis but in many cases this does not cover the entire loss, so a fund should be set aside for this insurance. Likewise insurance should be carried against depreciation by age.

This is sometimes termed depreciation of cattle but it embraces the actual valuation of the natural decreases. Such insurance should be carried on an animal even though she appreciates in value, for her value appreciates from the time she is two years old until she is five or six and depreciates after she is nine or ten years old. The period of usefulness is rather high unless

insurance is carried on depreciation. Usually a charge of $14\frac{1}{2}$ per cent is made for insurance.

6. *Method of determining the inventory.* Add the items in the inventory at the beginning of the year and add the items in the inventory at the end of the year. Add the credits and all items purchased. Add the credits to the inventory at the end of the year. Subtract the items purchased during the year from the inventory at the end of the year and the difference will be the true inventory of the old material at the end of the year. To find the depreciation, subtract the true inventory of the old material at the end of the year from the inventory at the beginning of the year and divide the difference by the inventory at the beginning of the year. This will give the per cent of depreciation.

For illustration: There are six milk cans on the farm at the beginning of the year, valued at $2 each, making a total inventory of $12 at the beginning of the year. During the year two of these are discarded; one sold for $2 and then new ones bought at $6 a can. At the end of the year the old ones are valued at $1 each, making the total value of the milk cans $21. Twelve dollars is the inventory at the beginning of the year and $21 the inventory at the end of the year. Add the credits—$2—and subtract $18 and there is a balance of $2, the amount of depreciation on cans. Divide by 12 and the per cent of depreciation which in this case is 41, is determined.

To find the inventory of the cows, add the inventories at the beginning of the year and at the end of the year. Add the values of the cows sold. Add the values of cows purchased. Add values of cows sold to the inventory at the end of the year; then subtract the value of the cows purchased. This will give the true inventory at the end of the year.

In valueing cows no extreme values are permitted. That is, a heifer may be appreciated naturally, but the appreciation must not be so great that it will show fictitious credits and lower the price of milk. The appreciation of the heifer must be taken care of from the fact that the heifer requires an extra amount of feed and a lesser amount of milk is produced for the feed consumed, than the mature cow. This loss can be made up by appreciation.

Anything in excess of this will reduce the price of milk. However, cows must be depreciated on their actual decline in value after they have reached the age of maturity which is usually five years.

THE PRODUCING HERD ACCOUNT

This differs from the individual cow account in that it requires less labor and is for the farmer who does not keep a detailed account of his cows. This simplifies the work and is for the purpose of determining the cost of 100 pounds of milk.

In this case the earnings include the milk sold plus the milk used on the farm, the calves and the manure.

The expenses are determined for the entire herd.

The cost of 100 pounds of milk is determined by adding the estimated value of the manure and the calf, subtracting this amount from the total expenses and dividing the difference by the pounds of milk sold plus that used on the farm.

For illustration: A man has ten cows and his expenses for one month are $200. Eight calves were born during the year with an estimated value of $40. The estimated value of the manure is $120, making a total value of $160 for the year or $16.67 for one month. Subtract $16.67 from $200, the total expense and there is left $183.33. Five thousand pounds of milk were sold and 1000 pounds used on the farm, making a total of 6000 pounds of milk. Divide $183.33 by 60 (60 hundred pounds) and the result is $3.05 or the cost of producing 100 pounds of milk on the farm.

If, however, cows are pastured, then manure shall be determined on the basis of actual production. For illustration: When cows are on pasture, the manure value is taken into consideration when estimating the value of the pasture; hence, during that month no credit shall be made for the manure. During the winter when all the manure is collected, full credit should be given for the manure.

FACTORS AFFECTING THE TOTAL BUTTER-FAT CONTENT OF COWS' MILK DURING A PERIOD OF TWO DAYS

W. M. REGAN AND S. W. MEAD

Dairy Department, New Jersey Agricultural Experiment Station, New Brunswick, New Jersey

In the supervision of advanced registry tests the New Jersey Agricultural Experiment Station requires that its supervisor shall see that each cow is "milked dry" at the milking preceding the test period. The supervision of this preliminary milking costs the breeders of pure-bred dairy cattle in New Jersey approximately $2500 each year.

The breed associations and some of the breeders have raised a question as to the necessity of the preliminary milking as a measure in the safe-guarding of the honesty and accuracy of the test. At the last meeting of the Dairy Science Association it was found that out of eleven states, seven require no preliminary milking, two leave the matter to the discretion of the superintendant of advanced registry of the state, and only two require a preliminary milking. It is their claim that thoroughness of milking would not be a factor affecting subsequent tests and consequently, the expense is a needless one. It was for the purpose of obtaining information on this point that the following outlined experiment was planned.

OUTLINE OF EXPERIMENT

The experiment involved the use of four cows in the college herd, two Holsteins, one Jersey, and one Ayrshire. The animals were selected, so far as possible, with regard to uniformity of stage of lactation and gestation, age and quantity of milk produced.

The feeding, housing and general care of the animals did not differ from that of the college herd.

Accurate account was kept of all feed consumed by each of the animals. Weight, height at withers and heart-girth measurements were taken every thirty days in order to have a check in case of any difficulties arising during the experiment. The cows were milked dry twice daily for six days. On the morning of the seventh day only half of the milk was drawn and during the four subsequent milkings the cows were again milked dry.

Samples were taken at each milking and tested for butter-fat. In this way it was possible to obtain an accurate comparison between the average butter-fat test before and after the partial milking. This proceedure was repeated twenty-seven times with the four cows.

It will be noted that tables 1, 2, 3 and 4 do not give the data for every day through-out the experimental period, but only for the milkings which have a direct bearing on the results of the trials and only for those trials in which approximately half of the milk was drawn during the milking at which such a procedure was planned. At the beginning of the experiment, milking machines were used but it was found difficult to calculate the point at which half the milk had been drawn. For this reason it was found advisable to use only hand milking and one man was placed in charge of the animals. In this way more careful attention was given to the milking. This man also did all of the testing thereby eliminating so far as possible any chances of error which might arise through different methods of conducting the Babcock test.

PRESENTATION OF DATA

Table 1, 2, 3 and 4 show the pounds of milk produced, the per cent of butter-fat and the pounds of butter-fat produced by each cow during the four milkings immediately preceding the partial milking, for the partial milking and during the four milkings immediately following the partial milking. Tables 5 and 6 were derived from tables 1, 2, 3 and 4 and show more clearly the result of the partial milking.

TABLE 1

Cow 416; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	9.0	8.4	8.2	6.5	9.5	7.7	7.00
a.m.	11.2	9.0	10.7	9.5	10.5	10.0	8.70
p.m.	9.2	8.7	7.6	9.0	8.8	7.2	6.60
a.m.	11.5	9.1	9.6	9.4	9.8	8.5	9.70
Average..	10.2	8.8	9.0	8.6	9.7	8.4	8.00

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	7.1	5.5	4.9	4.8	5.0	5.5	5.20

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	9.6	10.0	12.6	14.5	12.0	9.5	14.1
a.m.	12.4	8.5	7.8	9.0	9.7	9.1	10.2
p.m.	9.2	7.4	8.0	9.2	8.6	7.0	8.2
a.m	11.0	8.0	8.7	10.6	12.4	7.0	10.0
Average..	10.6	8.5	9.3	10.8	10.7	8.2	10.6

Percent fat

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m.	4.65	6.00	4.78	4.95	4.90	4.95	4.60
a.m.	4.95	4.55	4.45	4.05	4.60	3.90	4.28
p.m.	5.75	5.40	4.75		4.30	4.55	4.35
a.m.	4.05	4.75	4.25	4.30	4.95	3.80	4.45
Average..	4.81	5.15	4.53	4.37	4.69	4.25	4.41

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	4.28	3.70	3.70	3.90	3.05	3.50	3.35

TABLE 1—*Continued*

Percent fat

MILKING	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
Post period							
p.m	3.70	5 05	4 58	4.33	4.63	4.93	5.15
a.m.	5.60	5 35	4 48	5 05	5.38	4.58	5.20
p.m	6 05	4 80	4.00	5.13	4.50	4.08	4.55
a.m.	4.88	3.90	4.33	4.45	4.10	5.20	4.33
Average..	5.07	4.79	4 37	4.67	4.62	4.71	4.85

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0 4185	0.5040	0 3919	0 3217	0.4655	0.3811	0.3220
a.m.	0.5544	0 4095	0 4761	0 3847	0.4830	0 3900	0 3723
p.m.	0 5290	0.4698	0 3610		0.3784	0 3276	0 2871
a.m.	0 4657	0.4322	0.4080	0.4042	0 4851	0 3230	0.4316
Average..	0.4919	0.4538	0.4093	0 3702	0.4530	0.3554	0.3532

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	0.3038	0.2035	0.1813	0.1872	0.1525	0.1925	0.1742

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m	0.3552	0.5050	0.5770	0.6278	0.5556	0.4683	0.7261
a.m.	0.6944	0.4547	0.3494	0.4545	0.5218	0.4167	0.5304
p m	0.5566	0.3552	0.3200	0.4719	0.3870	0.2856	0.3731
a.m.	0.5368	0.3120	0.3767	0.4717	0.5084	0.3640	0.4330
Average..	0.5357	0.4067	0.4057	0.5064	0.4932	0.3836	0.5156

TABLE 2

Cow 322; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p m.	8.9	7 4	8 4	8 0	6 5	7.5	7.00
a.m.	10.9	9 5	10 1	9 2	9 3	10.0	10.00
p m	8 8	7 6	7 8	8.5	7.0	7.6	6.60
a.m.	11 5	9 3	9 7	8 7	9 5	10.5	10.30
Average..	10.0	8 5	9.0	8 5	8 1	8 9	8.4

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a m.	5 6	6 0	5 2	4 8	4 5	9 3	5.2

Post period

	FEBRUARY 13-15	FEBRUARY 27-MARCH 1	MARCH 6-8	MARCH 13-15	MARCH 20-22	MARCH 27-29	APRIL 3-5
p.m.	12 2	10 0	11 5	12 8	13 5	9 1	12.0
a.m.	9 0	10 0	8.5	8 0	8.7	10 4	9 8
p.m	8.3	7 5	7 3	8 2	8 3	7 3	7.5
a m.	10.4	10 2	8 9	8.4	10 2	11.0	10 6
Average..	10.0	9 4	9.1	9.4	10 2	9.5	9 9

Percent fat

	FEBRUARY 10-12	FEBRUARY 24-26	MARCH 3-5	MARCH 10-12	MARCH 17-19	MARCH 24-26	MARCH 31-APRIL 2
Preceding Period							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m	5.00	5 15	4 88	4 78	4 85	5.05	4.63
a.m.	5.05	5 25	4.70	4.75	4.60	4.60	4.78
p.m.	4.93	5.25	5 33	4.70	4.68	4.83	4.73
a.m.	4.83	5.00	4.80	5.15	4.68	4.63	4.48
Average .	4.94	5.15	4.90	4.84	4.69	4.75	4.64

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	3.85	3.90	4.00	3 75	2 28	2 80	3.28

TABLE 2—*Continued*

Percent fat

MILKING	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
Post period							
p.m.	6.00	5.70	5.30	4.70	5.40	4.70	5.85
a.m.	6.05	5 80	5.43	5.55	5 35	5.10	5.45
p.m.	5.13	5.20	5.08	5.90	4.40	4.75	4.90
a.m.	4.78	4 95	4.78	5.40	4.65	5.05	4.78
Average..	5 51	5 42	5.15	5 30	4.99	4.92	5.28

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0.4450	0.3811	0.4099	0.3824	0.3152	0.3787	0.3241
a.m.	0 5504	0.4987	0.4747	0.4370	0.4278	0.4600	0.4780
p.m.	0.4338	0.3990	0.4157	0.3995	0.3276	0.3670	0.3121
a.m.	0.5554	0.4650	0.4656	0.4480	0.4446	0.4861	0.4614
Average..	0.4961	0.4359	0.4414	0.4167	0.3788	0.4229	0.3939

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	0.2156	0.2340	0 2080	0.1800	0.1026	0.2604	0.1705

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	0.7320	0.5700	0.6095	0.6016	0.7290	0.4277	0.7020
a.m.	0.5445	0.5800	0.4615	0.4440	0.4654	0.5304	0.5341
p.m.	0.4257	0.3900	0.3708	0.4838	0.3652	0.3467	0.3675
a.m.	0.4971	0.5049	0.4254	0.4536	0.4743	0.5555	0.5066
Average..	0.5498	0.5112	0.4668	0.4957	0.5084	0.4650	0.5275

TABLE 3

Cow 71; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	14.4	12.1	13.8	13.8	13.7	11.8	13.0
a.m.	16.0	14.4	17.0	17.0	17.4	16.5	17.2
p.m.	13.8	12.3	13.9	14.7	12.7	14.0	13.4
a.m.	17.8	13.5	17.1	16.5	17.0	16.5	17.2
Average..	15.5	13.0	15.4	15.5	15.2	14.7	15.2
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	9.0	11.0	8.5	8.8	7.5	7.6	8.6
Post period							
	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	10.1	16.0	20.3	22.0	20.8	17.0	19.7
a.m.	16.1	14.0	14.9	15.8	17.1	14.7	19.2
p.m.	12.2	11.4	14.4	15.6	14.1	12.6	13.6
a.m.	16.9	18.1	16.5	17.6	18.0	17.9	17.6
Average..	13.8	14.8	16.5	17.7	17.5	15.5	17.5
Percent fat							
	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m.	3.60	3.30	2.98	3.10	3.23	3.48	3.30
a.m.	3.63	3.50	3.03	2.83	3.05	2.83	2.83
p.m.	3.45	3.60	3.48	3.20	3.15	3.33	3.45
a.m.	3.50	3.45	3.18	2.80	3.18	2.83	3.10
Average..	3.54	3.46	3.16	2.96	3.14	3.07	3.14
Partial milking							
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	2.70	2.50	2.45	2.33	1.65	1.95	2.20

TABLE 3—*Continued*

Percent fat

MILKING	FEBRUARY 12–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
Post period							
p.m.	3 35	3.75	3.50	3.45	3.85	3.83	3.20
a.m.	4.00	3.48	2.80	3 28	3.30	3.50	3.20
p.m.	3 55	3.35	3 65	3.30	3.05	3.50	3.05
a.m.	3.40	3.00	3 15	3.15	2.78	3.78	2.78
Average..	3.59	3 38	3 28	3 30	3.27	3.67	3.06

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 24–26	MARCH 31–APRIL 2
Preceding period							
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0 5184	0.3993	0 4112	0.4278	0.4425	0.4106	0.4290
a.m.	0 5808	0 5040	0.5151	0 4811	0.5307	0.4669	0 4867
p.m.	0 4761	0.4428	0.4837	0.4702	0.4000	0.4662	0.4623
a.m.	0.6230	0.4657	0.5437	0.4620	0.5406	0.4669	0.5332
Average..	0 5495	0.4529	0.4884	0.4602	0.4784	0.4526	0.4778

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	MARCH 27	APRIL 3
a.m.	0.2430	0.2750	0.2082	0.2050	0.1237	0.1482	0.1892

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	MARCH 27–29	APRIL 3–5
p.m.	0.3383	0 6000	0.7105	0.7590	0.8008	0.6511	0.6304
a.m.	0.6440	0.4872	0 4172	0.5182	0.5643	0.5145	0.6144
p.m.	0.4331	0.3819	0 5256	0.5148	0.4300	0.4410	0.4148
a.m.	0.5746	0.5430	0 5197	0.5544	0.5004	0.6766	0.4892
Average..	0.4971	0.5029	0.5432	0.5866	0.5738	0.5708	0.5372

TABLE 4

Cow 59; record of milk and butter-fat produced and percent of fat

Milk

MILKING	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 31–APRIL 2
			Preceding period			
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	11.5	10.7	10.5	10.5	9.9	10.1
a.m.	12.5	13.0	12.6	12.0	12.6	11.8
p.m.	11.0	10.8	10.1	10.0	9.1	9.2
a.m.	13.7	12.0	12.8	11.8	12.5	12.0
Average	12.1	11.6	11.5	11.0	11.0	10.7
			Partial milking			
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	APRIL 3
a.m.	7.7	10.2	6.3	6.5	6.1	6.3
			Post period			
	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	APRIL 3–5
p.m.	10.3	11.0	12.6	13.5	12.4	7.9
a.m.	12.6	12.3	11.2	11.6	11.6	12.6
p.m.	10.0	10.2	9.8	11.6	10.4	9.5
a.m.	12.5	13.4	11.5	12.2	12.3	11.6
Average	11.3	11.7	11.2	12.2	11.6	10.4

Percent fat

	FEBRUARY 10–12	BEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 24–26	MARCH 31–APRIL 2
			Preceding period			
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
p.m.	3.90	3.78	3.95	4.03	3.85	4.50
a.m.	3.70	3.88	3.60	3.80	3.75	3.85
p.m.	4.13	4.20	4.20	3.90	3.80	3.90
a.m.	4.05	4.10	4.05	3.88	3.83	3.95
Average	3.94	3.98	3.93	3.89	3.80	3.92
			Partial milking			
	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	APRIL 3
a.m.	2.60	3.20	2.55	2.88	2.40	2.80

TABLE 4—*Continued*

Percent fat

MILKING	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	APRIL 3–5
Post period						
p.m.	3.88	4 50	5 00	4 70	5.15	5.60
a.m.	4.45	4.23	4.25	4.18	3.90	4.85
p m.	4.20	4.15	4.70	4.70	3.78	3.78
a.m.	3.90	4.00	4.30	3 83	4.05	4.10
Average	4.11	4 21	4.57	4.35	4.24	4.53

Butter-fat production

	FEBRUARY 10–12	FEBRUARY 24–26	MARCH 3–5	MARCH 10–12	MARCH 17–19	MARCH 31–APRIL 2
Preceding period						
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
p.m.	0.4485	0.4044	0.4147	0.4231	0 3811	0.4090
a.m.	0.4625	0.5044	0 4536	0 4560	0.4725	0.4519
p.m.	0.4543	0.4536	0 4242	0 3900	0 3458	0 3588
a.m.	0.5548	0 4920	0 5184	0.4578	0.4787	0.4740
Average	0 4800	0.4636	0 4527	0.4317	0.4195	0.4234

Partial milking

	FEBRUARY 13	FEBRUARY 27	MARCH 6	MARCH 13	MARCH 20	APRIL 3
a.m.	0 2002	0 3264	0.1606	0 1872	0.1464	0.1764

Post period

	FEBRUARY 13–15	FEBRUARY 27–MARCH 1	MARCH 6–8	MARCH 13–15	MARCH 20–22	APRIL 3–5
p.m.	0 3996	0.4950	0 6300	0.6345	0.6386	0.4424
a.m.	0.5607	0.5202	0.4760	0.4848	0.4524	0.6112
p.m.	0.4200	0.4233	0.4606	0.5452	0.3931	0.3591
a.m.	0.4875	0.5360	0.4945	0 4672	0.4981	0.4756
Average	0.4669	0.4936	0.5152	0.5329	0.4955	0.4720

TABLE 5

Showing differences between milk and fat production and per cent butter-fat before and after partial milking

TRIAL NUMBER	MILK	FAT	BUTTER-FAT
		Cow 416	
	pounds	*per cent*	*pounds*
1	+0.4	+0 26	+0.0438
2	−0 3	−0 36	−0.0471
3	+0.3	−0 16	−0.0036
4	+2.2	+0.30	+0.1362
5	+1.0	−0.07	+0.0402
6	−0 2	+0 46	+0.0282
7	+2.6	+0.44	+0.1624
		Cow 322	
1		+0 57	+0.0537
2	+0.9	+0 27	+0.0753
3	+0 1	+0 25	+0.0254
4	+0.9	+0 46	+0.0790
5	+2.2	+0 30	+0.1296
6	+0.6	+0.17	+0.0421
7	+1 5	+0.64	+0.1336
		Cow 71	
1	−1.7	+0.05	−0.0524
2	+1.8	−0.08	+0.0500
3	+1.1	+0.12	+0.0548
4	+2.2	+0.34	+0.1264
5	+2.3	+0.13	+0.0954
6	+0.8	+0.60	+0.1182
7	+2 3	−0.08	+0.0594
		Cow 59	
1	−0.8	+0.17	−0.1031
2	+0.1	+0.23	+0.0300
3	−0.3	+0.64	+0.0625
4	+1.2	+0.46	+0.1012
5	+0.6	+0.44	+0.0760
6	−0.3	+0.61	+0.0486

+ = Increase of post period over preceding period.

THE EFFECT ON PERCENT FAT

The 108 milkings following the 27 partial milkings showed an average test of 0.27 per cent higher than the 108 milkings preceding the 27 partial milkings. It will be noticed that during some of the trials there was a slight decrease in per cent fat, but each of the four animals showed an increase when all of the trials were considered. The figures apparently show no preference to breed in that one Holstein made an average increase of 0.425 in per cent of butter-fat while the other made only 0.154 increase in per cent of butter-fat. However, the average for these two animals was higher than either the Jersey or the Ayrshire. The increase in the fat percentage shown by the Jersey and Ayrshire averaged 0.380 and 0.124 respectively.

TABLE 6

Average increase in milk and butterfat production and per cent fat for each individual during seven trials

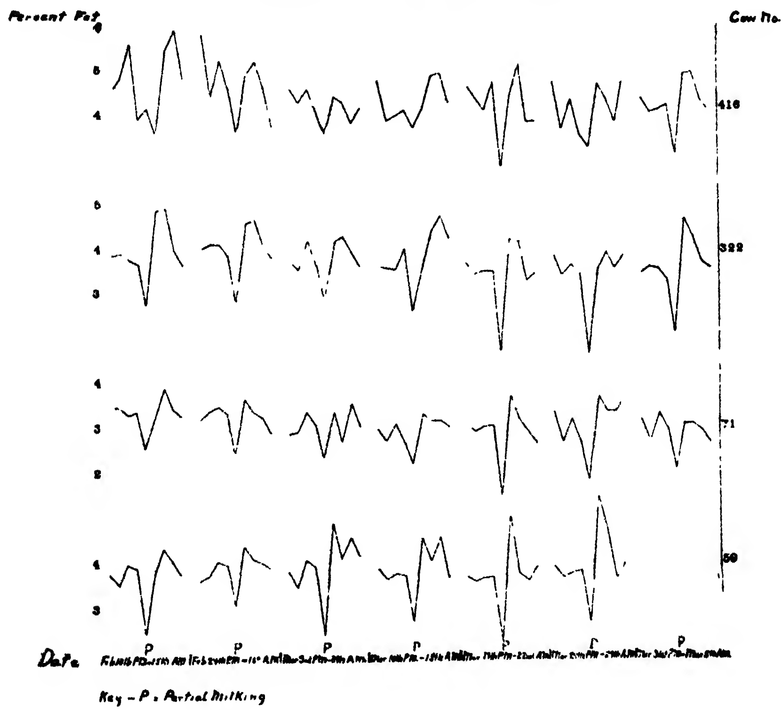
COW NUMBER	MILK	FAT	BUTTER-FAT
	pounds	*per cent*	*pounds*
59	0.08	0 425	0.0508
71	1.25	0.154	0.0645
322	.88	0 38	0.0769
416	.857	0.124	0.0514
Average..........	.766	0 270	0.0609

The average increase of 0.27 per cent in fat would not seem very large. However, in the case of a cow producing 20,000 pounds of milk per year this increase of 0.27 per cent would add 54 pounds to her yearly butter-fat production. During several of the trials the increase was far in excess of the average. Table 5 shows that in one trial there was an increase of over 6 percent and in 10 others there was an average increase of over 0.53 per cent. Taking this into consideration the date collected would indicate that while the average for all trials was only 0.27 it would be possible, however, to obtain a much larger increase in percent of butter-fat.

Graph 1 reveals an interesting feature of the experiment. It would be expected that the highest fat percentage would be reached at the milking following the partial milking. Graph 1 shows that this is not always the case, since out of the 27 trials there were 12 in which the butter-fat percentage was

GRAPH NO. I

SHOWING FAT TESTS BEFORE AND AFTER PARTIAL MILKING



higher at the second milking than it was for the milking immediately following the partial milking.

THE EFFECT ON THE PRODUCTION OF MILK

The average milk production for the 108 milkings following the 27 partial milkings averaged 0.766 pounds more than the 108

milkings preceding the 27 partial milkings. The increase is very slight when we consider that it was made during four milkings, which would mean an increase of only 0.191 pounds per milking.

The average production of the four cows before the partial milking was 10.98 pounds. On the average 3.8 pounds of milk were left in the udder of each cow at the partial milking. Since there was an increase of only 0.191 pounds of milk it is assumed that the rest of the milk was either reabsorbed in the udder or that milk secretion was temporarily checked or possibly both were factors affecting the four subsequent milkings.

Table 7 is interesting though possibly not conclusive in view of fact that only four cows were used.

TABLE 7

Pounds of milk left in udder estimated in per cent of normal production compared with the average increase in per cent of fat

COW NUMBER	AVERAGE MILK PRODUCTION	MILK LEFT IN UDDER	INCREASE IN PER CENT FAT	MILK LEFT IN UDDER
	pounds	*pounds*		*per cent*
59	11 31	4.13	0.425	36.5
322	8.77	2.97	0 380	33 8
71	14.92	6.18	0.154	41.3
416	8.95	3 52	0.124	39.3

According to the figures shown in table 7 the cows which had the least milk left in the udder at the partial milking showed the highest increase in percent of butter fat. It would seem from this that by leaving too much milk in the udder there would not be an increase in per cent of fat but that by leaving a certain percentage of milk in the udder the maximum increase would be obtained.

SUMMARY

It was found possible in this experiment to increase the percentage of butter-fat in milk during a period of two days by leaving half of the milk in the udder during the milking prior to the two-day period. Although the average increase in percent of butter-fat was only 0.27, the data collected would seem

to indicate that it is possible to get an increase of over 0.5 in percent of butter-fat.

The highest fat percentage was not always reached at the milking following the partial milking. Out of the 27 trials there were 12 in which the highest fat percentage was reached the second milking after the partial milking.

If in advanced registry work a practice was made of leaving a part of the milk in the udder prior to the two day test; our figures would indicate that such a practice could not be detected by a study of the cows milk record; since there was an average increase of only 0.766 pounds of milk for the period following the partial milking.

The data collected in this experiment indicates that a preliminary milking is necessary as a measure in the safe-guarding of the honesty and accuracy of advanced registry testing.

YEASTS AND OIDIA IN HIGH-GRADE EXPERIMENTAL BUTTER

WILLIAM R. NORTH, JR. AND GEORGE F. REDDISH[1]

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.

In studying butter, Redfield[2] has proposed a routine microscopic method of counting yeasts and oidia as correlated in some degree at least with the quality of the cream used in its manufacture. This method is based upon the examination of the curd-whey mixture separating out when the sample of butter is melted at 45°C. One-cubic centimeter samples of this mixture are removed to sterile containers and smears are made by transferring 0.01 cc. samples of this mixture to slides with the Breed type of pipette, for microscopic study. The results shown in table 1 are selected from experiments made to test the accuracy of this method.

These results based on the number of yeasts found in 10 microscopic fields, check as closely as those usually obtained by the official plate method, and therefore indicate that yeasts are fairly evenly distributed throughout the butter. Counts of this kind, check fairly closely when the totals are high as in these samples. Much greater differences occur in successive examinations of samples containing very low numbers of yeasts.

These counts were based on numbers found in 100 microscopic fields. Each cell found was counted.

The results indicate that yeasts are somewhat more evenly distributed than are the oidia. The mycelial character of Oidium lactis tends to result in more uneven distribution of the

[1] The authors wish to express their appreciation to Dr. Charles Thom of the Microbiological Laboratory of the Bureau of Chemistry for his kindly assistance in the preparation of this paper.

[2] In case the curd does not completely separate from the butterfat after fifteen minutes at 45°C., slow centrifuging of the tube for about one minute while the melted butter is at the above temperature will bring all the curd to the bottom of the tube. It is essential that there be a clear separation of the curd from the butterfat.

vegetative elements of the oidia than is found to be true in studying yeasts.

The commercial samples of butter and cream used by Redfield represented chiefly lower grades, hence failed to establish a relation to cream and butter of high quality. To obtain information as to the abundance of these forms in the higher grades of cream, a series of studies were made during the summer of 1920 at the Experimental Creamery Laboratory of the Dairy

TABLE 1

Yeasts in samples from different parts of the same butter

NUMBER	TUBE I	TUBE II	TUBE III	TUBE IV
538 B	1,060,000	1,200,000	2,350,000	1,500,000
540 B	810,000	950,000	550,000	850,000

TABLE 2

Counts from different smears of the same sample of curd-whey mixture

NUMBER	(a)	(b)	(c)	ORGANISMS
301 B1	2,280,000	2,790,000	2,490,000	Yeasts
302 B1	150,000	160,000	585,000	Oidia
303 B2	250,000	225,000	245,000	Yeasts
232 B1	55,000	75,000		Oidia
232 B3	225,000	260,000		Oidia
236 B1	1,370,000	750,000	860,000	Oidia
236 B2	610,000	780,000	2,140,000	Oidia
237 B1	160,000	55,000	25,000	Oidia
237 B1	340,000	215,000	155,000	Yeasts

Division, Bureau of Animal Industry of this Department at Grove City, Pennsylvania, which is conducted in close cooperation with the commercial manufacture of pasteurized sweet cream butter of exceptionally high grade. The samples taken for examination were thus obtained from commercial vats of cream which were subsequently made into butter scoring 93 or over. Samples of this butter, as freshly made, were examined microscopically, and reserve samples were packed in 1-pound cans sealed and stored for later examination.

Table 3 gives the microscopic and cultural results obtained in examining 14 samples of cream which in every case produced butter scoring 93 or 94 (see table 4). Since the microscopic method used (see Redfield) introduces a factor of 500,000, one organism in each microscopic field would represent 500,000 per cubic centimeter of material examined. In the table therefore "–5000" represents failure to find a single organism in examining 100 fields. Since no oidia were found with the microscope the

TABLE 3

Microscopic and plate counts of yeasts, oidia and bacteria in sweet raw cream

NUMBER OF CREAM	MICROSCOPIC COUNT			PLATE COUNT WHEY AGAR 30°C.—5 DAYS		
	Yeasts	Oidia	Bacteria*	Yeasts	Oidia	Bacteria*
200 C	–5,000	–5,000	61,000,000	110	30	32,240,000
201 C	–5,000	–5,000	40,000,000			
202 C	5,000	–5,000	117,000,000	3,800	500	49,000,000
203 C	65,000	–5,000	100,000,000	2,100	125	95,500,000
204 C	5,000	–5,000	39,000,000	1,200	100	39,500,000
205 C	75,000	–5,000	44,500,000	40	40	35,500,000
206 C	–5,000	–5,000	110,000,000	850	100	
207 C	5,000	–5,000	53,500,000			
208 C	–5,000	–5,000	34,000,000			
210 C	25,000	–5,000	132,000,000	1,100	100	
211 C	7,500	–5,000	80,000,000	350	–100	
213 C	5,000	–5,000	60,000,000	5,200	200	75,000,000
214 C	30,000	–5,000	100,000,000	895	25	85,000,000
215 C	–5,000	–5,000	100,000,000	4,600	100	

* Microscopic count of bacteria wherever made in this paper was based on groups of bacteria rather than on the enumeration of individuals. The figures for yeasts and oidia include every cell found.

counts of viable organisms in the column reporting the cultural examinations, represent the actual numbers of viable oidia present with a maximum of 500 per cubic centimeter. These figures show that even in cream passed by physical examination as high in quality both yeasts and oidia are present in numbers sufficient to account as inoculating material for the tremendous numbers found later in samples of the same cream when subjected to incubation.

TABLE 4

Microscopic counts of yeasts and Oidium lactis in cream, fresh butter, same butter after transit and after storage

NUMBER OF BUTTER	FRESH BUTTER				AFTER TRANSIT TO WASHINGTON*				AFTER STORAGE AT 22° F.†			
	Score	Salt	Yeasts	Oidia	Age when examined	Score	Yeasts	Oidia	Time in storage	Score	Yeasts	Oidia
		per cent			*days*				*days*			
200 B	93	2.0	−5,000	−5,000	13	94	2,020,000	−5,000	155	94 0	705,000	−5,000
201 B	94	2.2	−5,000	−5,000	13	93	1,730,000	−5,000	154	93.5	470,000	−5,000
202 B	94	2.0	−5,000	−5,000	13	93	540,000	−5,000	156	92 0	585,000	−5,000
203 B	94	2 4	−5,000	−5,000	13	93	215,000	−5,000	155	93.0	260,000	−5,000
204 B	94	3.2	−5,000	−5,000	19	94	215,000	−5,000	161	93.0	380,000	−5,000
205 B	94	2.2	−5,000	−5,000	11	94	450,000	−5,000	155	93.0	60,000	−5,000
206 B	94	2.4	−5,000	−5,000	23	93	4,240,000	−5,000	157	92.0	6,230,000	−5,000
207 B	94	2.0	−5,000	−5,000	21	94	340,000	−5,000	164	93.0	1,250,000	−5,000
208 B	94	3.3	−5,000	−5,000	19	94	165,000	−5,000	166	93.0	130,000	−5,000
210 B	94	2.0	−5,000	−5,000	25	93	1,085,000	−5,000	180	93.0	1,440,000	−5,000
211 B	93	2.0	−5,000	−5,000	19	92	1,425,000	−5,000	180	93.0	350,000	−5,000
213 B	94	2.2	−5,000	−5,000	26	93	8,150,000	−5,000	180	93.0	3,815,000	−5,000
214 B	94	3.0	−5,000	−5,000	22	93	5,290,000	−5,000	179	93.0	3,770,000	−5,000
215 B	94	2.4	−5,000	−5,000	15	92	750,000	−5,000	170	92.5	370,000	−5,000

* After one to seven days at 40–45° F., transit to Washington, and one to three days at 12°F.

† Placed in storage in Washington.

The absence of oidia in the microscopic counts of high-grade cream shows marked contrast to the large numbers found in most of his samples by Redfield. The occasional presence of yeasts in numbers under 100,000 was clearly unaccompanied by physical evidence of lowered quality. The cream was sampled from a large pasteurizing vat before heating had begun, and represents the mixed product of many producers. Titration showed the acidities of these samples to vary from 0.15 to 0.17 per cent, but no cream showing physically noticeable acidity was accepted. These vats of cream represented mixed lots which varied in age from a few hours to forty-eight hours old, but all of which had been well-cooled on the farm. Microscopic counts before pasteurizing showed bacterial numbers already running from 34,000,000 to 132,000,000. Experimental samples from certain of these commercial vats of cream were removed to the laboratory and held for further study at 70 to 80° F. These samples were titrated from time to time and pasteurized at the desired acidities which ran in series from 0.20 to 0.34 per cent and required increasing periods up to six hours for their development, and were accompanied by microscopic counts of bacteria running to 300,000,000. Cream in the condition at which these samples were taken into the creamery, would sour quickly if not pasteurized or refrigerated promptly.

TREATMENT OF CREAM AND BUTTER

The mixed cream was pasteurized in a large vat at 145° for thirty minutes. After cooling, it was kept at 45°F. in the same vat for about twelve hours. The cream was protected from contamination during that time. It was then churned sweet in a large revolving churn. No starter was used.

Samples were taken directly from the churn for immediate microscopic examination and for storage in canned form. The results of this examination are combined with the findings of subsequent examinations to form table 4. The microscopic counts of yeasts and oidia are seen to be less than 5000 per cubic centimeter of the curd-whey mixture, in every sample. In other words, no yeasts nor oidia were found when 100 fields of

the microscope were examined. Cultures made from these samples showed small numbers of yeasts and oidia; the maximum number was roughly 300 yeasts and 100 oidia per gram of butter, but both groups were found present in viable condition in the samples examined. Bacterial colonies found in the cultures ranged from 10,000 to 130,000. The samples taken from the churn and canned were first stored in the creamery refrigerator at 40 to 45° F. for one to seven days, then shipped by express to Washington, D. C. It was not possible to control the temperatures at which the butter was held in transit. The exposures were supposed to have been approximately as follows: About five hours at ordinary baggage car temperature, about eight hours at express-car refrigerator temperature, about one hour at summer temperatures during transportation from the railroad station to the Bureau of Chemistry. All samples were then stored at 22°F.

After one to three days storage in Washington two cans of each series were opened and examined. The differences in score found were not great and might represent the differences in opinion of the judges. All these samples showed an increased microscopic count of yeasts at this time. Varied increases are noted. Since these samples were shipped at different times during the summer months, they were not subjected to the same conditions of transportation or for the same period of storage at 45° F. in Grove City. No increase in oidia appeared. This organism does not grow in salted butter. The large increases in numbers of yeasts found in examining these samples are apparently only important as showing a multiplication factor in this butter subjected to temperatures above freezing. The indications are that the actual number of yeasts in a sample of butter can not be correlated with the condition of the cream unless the examination is made immediately after churning, or unless the butter is kept thoroughly chilled or unless the yeasts have been all killed by pasteurization. Samples of these same lots were held at 22° F. for five to six months and again examined (also in table 4). The scores remain practically unchanged. The oidia counts are unchanged. A few increases in numbers of yeasts are offset by a larger number of decreases.

TABLE 5

Storage butter held two weeks at 50°F.

NUMBER OF BUTTER	SCORE WHEN REMOVED FROM STORAGE	MICROSCOPIC COUNT		SCORE AFTER TWO WEEKS IN THE ICE-BOX	MICROSCOPIC COUNT		ORGANISMS DEVELOPING PER CUBIC CENTIMETER OF CURD-WHEY MIXTURE ON WHEY AGAR IN 5 DAYS AT 30° C.		ORGANISMS DEVELOPING PER GRAM OF BUTTER ON WHEY AGAR IN 5 DAYS AT 30° C.	
		Yeasts	Oidia		Yeasts	Oidia	Total	Yeasts	Total	Yeasts
200 B	94.0	705,000	−5,000	92.0	4,332,000	−5,000	2,100,000	2,100,000	520,000	520,000
201 B	93.5	473,000	−5,000	91 5	360,000	−5,000	−10,000	−10,000	−10,000	−10,000
202 B	92.0	585,000	−5,000	92.5	470,000	−5,000	10,000	10,000	−10,000	−10,000
203 B	93.0	260,000	−5,000	92.0	800,000	−5,000	350,000	350,000	50,000	50,000
205 B	93.0	60,000	−5,000	91.0	395,000	−5,000	70,000	−10,000	66,000	−1,000
206 B	92.0	6,230,000	−5,000	88.0	12,550,000	−5,000	4,300,000	4,300,000	410,000	410,000
207 B	93.0	1,250,000	−5,000	88.0*	1,790,000	−5,000	60,000	60,000	30,000	30,000
208 B	93.0	130,000	−5,000	89.0†	100,000	−5,000	910,000‡	—	40,000‡	—
210 B	93.0	1,440,000	−5,000	93.0	1,750,000	−5,000	170,000	170,000	100,000	100,000
215 B	92.5	370,000	−5,000	91.0	6,860,000	−5,000	1,000,000	1,000,000	20,000	20,000

* Metallic, bordering on fishy flavor.

† Stale flavor.

‡ Bacteria predominated so it was impossible to find the number of yeasts.

TABLE 6

Microscopic examination of wholesale samples of butter in New York

NUMBER OF BUTTER	SCORE	COMMENTS OF SCORER	NEW YORK RESULTS (G. F. R). Microscopic count	
			Yeasts	Oidia
831	95		−10,000	−10,000
810	94		70,000	−10,000
824	94	Sweet cream butter	7,250,000	−10,000
830	94	Creamery	−10,000	−10,000
845	94		−10,000	−10,000
809	93	Sweet, clean	100,000	170,000
814	93	Creamery	150,000	50,000
825	93		180,000	−10,000
828	93	Sweet cream	−10,000	−10,000
842	93	Sweet, clean	375,000	50,000
846	93		120,000	20,000
849	93	Creamy	10,000	−10,000
803	92	Sweet	1,600,000	−10,000
811	92		350,000	−10,000
815	92		220,000	10,000
821	92	Unsalted	240,000	−10,000
822	92		700,000	−10,000
829	92		−10,000	−10,000
843	92		−10,000	−10,000
813	91	Weedy	80,000	30,000
818	91	Slightly lardy	10,000	−10,000
823	91	Flat, low salt, Holland	5,100,000	−10,000
844	91		−10,000	−10,000
848	91	Tainted, unclean	10,000	−10,000
801	90	Little oily	650,000	30,000
805	90	Little oily	150,000	−10,000
812	90	Little oily	260,000	20,000
816	90	Little oily	40,000	−10,000
826	90	Curdy, lardy	180,000	380,000
850	90	Little curdy, acid	350,000	300,000
857	90	Flat	1,450,000	−10,000
827	89	Slightly oily, weedy	550,000	−10,000
851	89	Old flavor	240,000	200,000
856	89	Acidy	3,050,000	850,000
804	88	Unclean, sour	550,000	130,000
806	88	Slightly fishy	400,000	100,000
807	88	Oily, stale, slightly fishy	250,000	140,000
817	88	Oily, slightly fishy	100,000	−10,000
853	88	Sour	150,000	550,000

TABLE 6—*Continued*

NUMBER OF BUTTER	SCORE	COMMENTS OF SCORER	NEW YORK RESULTS (G. F. R.) Microscopic count	
			Yeasts	Oidia
802	87	Stale, oily, little fishy	100,000	60,000
808	87	Fishy flavor	200,000	450,000
820	87	Fishy flavor	120,000	−10,000
847	87	Distinctly fishy	340,000	120,000
862	87	Whey butter	4,650,000	100,000
819	86	Pronounced fishy flavor	−10,000	−10,000
852	84	Stale, weedy, tallowy	1,600,000	350,000
855	84	Rank, weedy, very high salt	400,000	300,000
860	84	Pronounced fishy	480,000	40,000
858	83	Rank, stale, sour	220,000	120,000
859	83	Rank, stale, weedy	1,550,000	850,000
861	83	Tallowy	1,450,000	400,000

Cans representing 10 of the samples in this series were then removed from cold storage and held in the ice-refrigerator at about 50° F. for two weeks and examined (table 5). No development of oidia is shown, but the numbers of yeasts show a positive increase in 5 samples. The score of these samples shows deterioration but not correlated with the numbers of yeasts found, since increases of yeasts are in some cases unaccompanied by change in score and changes in score are in other samples not accompanied by increased numbers of yeasts.

Counts of colonies developing in whey-agar are given in table 5 for these 10 samples. In these cultures yeasts dominated. Bacteria appeared in only one sample in appreciable numbers. One sample showed no colonies of any organism in the ten thousandth of a cubic centimeter. Wort agar plates, however, showed viable oidia in every sample in numbers varying from 10 to 600 per cubic centimeter. This species was clearly held in check by salt in the butter.

For comparison with this group of samples table 6 is introduced to include a series of samples of butter of unknown history taken in wholesale warehouses in New York. In this series the general contrast between low counts of oidia in higher scoring

TABLE

NUMBER	CREAM						FRESH BUTTER		
	Period of inoculation	Temperature	Flavor of cream	Acidity	Microscopic count		Microscopic count		Score
					Yeasts	Oidia	Yeasts	Oidia	
220 C1	18 hours	75°–80°F.	Clean acid	0.58	–5,000	–5,000	–5,000	–5,000	92
221 C1	18 hours	75°–80°F.	Clean acid	0.51	10,000	–5,000	60,000	–5,000	92
228 C1	24 hours	75°–80°F.	Clean acid	0 63	–5,000	–5,000	–5,000	–5,000	91
219 C1	24 hours	75°–80°F.	Clean acid	0 67	–5,000	–5,000	10,000	–5.000	92
223 C1	2 days	75°–80°F.	Clean acid	0 70	85,000	125,000	40,000	165.000	89 Stale typical centralizer
209 C3	4 days	75°–80°F.	Slightly stale	0 79	790,000	770,000	350,000	275,000	89 Stale dish rag flavor
232 C3	4 days	75°–80°F.	Slightly stale	0 87	30,000	880,000	25,000	260.000	88 Stale
203 C1	5 days	75°–80°F.	Slightly cheesy	0 82	400,000	640,000	230,000	1.320,000	90 Stale old cream
229 C2	5 days	50°F.	Clean acid	0 64	30,000	–5,000	–5,000	–5.000	92
236 C1	9 days	75°–80°F.	Medium stale	0 96	1,880,000	3,210,000	105,000	996,000	87 Very stale old cream

lots and very high counts in the low scoring lots is maintained. No absolute correlation, however, is established between count of either group and score.

Experiments to test further the significance of the numbers of oidia found are brought together in table 7. These samples of cream probably averaged twenty-four hours old at the time they were taken from the commercial vat. After twenty-four hours in the laboratory (at 70 to 80° F.) no sample showed 5000 oidia per cubic centimeter. After two days, marked increase was found for both yeasts and oidia accompanied by curdling from the development of acid bacteria. The numbers of oidia in both cream and butter rises rapidly with the age of the cream except in sample 229 C2, which was held in the refrigerator at 50° F. for comparison. These numbers compare with similar results given by Redfield. Under the butter-making conditions of these experiments, microscopic counts of above 5000 oidia in the curd-whey mixture indicated the use of cream both sour and stale in flavor in the manufacture of the product.

In general, these studies indicate that a microscopic count of yeasts and oidia by the Redfield method can be made to show the relative numbers of these organisms present in samples of butter.

No sample of high-grade cream and no sample of salty butter made from such cream showed 5000 oidia in these experiments.

In the first-grade sweet cream used, the number of yeasts usually fell below 5000, but certain samples contained up to 75,000 yeasts per cubic centimeter without showing physical signs of deterioration.

Under the condition of handling represented in these Grove City samples of cream which showed less than 100,000 yeasts and less than 5000 oidia, bacterial multiplication had already reached figures of 34,000,000 to 132,000,000. Cream showing these numbers of bacteria is close to the turning point in flavor.

In a commercially salted butter, there is an apparent correlation between the presence of oidia in appreciable numbers (50,000 and over is suggested) and the use of old stale or deteriorated cream in its manufacture.

THE VOLATILE ACIDS AND THE VOLATILE OXIDIZABLE SUBSTANCES OF CREAM AND EXPERIMENTAL BUTTER

L. W. FERRIS, H. W. REDFIELD AND W. R. NORTH

Bureau of Chemistry, United States Department of Agriculture, Washington, D. C.[1]

In judging the fitness of cream for butter-making, the odor is generally considered as one of the most important factors. Van Slyke and Baker[2] observe that there is a characteristic flavor due, not to lactic acid, but to the presence of some volatile compound which appears in milk even before it begins to taste sour. In this study, the volatile acids and the "oxidizability value"[3] of cream and butter have been considered in their relation to the quality of cream and of the butter made from different grades of cream and the changes that take place during storage under different conditions.

A method for determining the rancidity of fat and oils, is given by Issoglio,[4] who found that when the "oxidizability value" is above 15, that the fat is rancid or that some other change has taken place. Brill and Parker,[4] working on cocoanut oil, found that although some samples, which were undoubtedly rancid, gave a low oxidizability value, however, when this value was high, the oil was always rancid. Kerr[5] found results that, in the main, confirmed the standards set by Issoglio, but, observing that most of the oxidizable substances are soluble in water, preferred to wash the fat or oil with water and oxidize the washings rather than distil with steam.

In order to measure the oxidizable substances produced by decomposition in cream and butter, the original sample, in

[1] Acknowledgment is hereby made to L. Jones, J. I. Palmore, Miss Scott, Miss Offutt and Miss Dean of this Bureau, for assistance in chemical analyses and to the Butter Experts of the Dairy Division of this Department for scoring the samples of butter.

[2] Free lactic acid in sour milk. Jour. Biol. Chem., xxxv, 178.

[3] Annali. chim. Applic., 1916, vi, 1–18.

[4] Philippine Jour. Sci., 1917, xii, 95–110.

[5] Jour. Ind. & Eng. Chem., x, no. 6, p. 471.

each case, was subjected to steam distillation and the distillate oxidized according to the procedure given by Issoglio. Since, in this case, other substances than fat are present, it could not be expected that the values obtained would be strictly comparable to those given by Issoglio, but the values found on cream and on butter should represent, in each case, the relative amount of volatile, oxidizable substances present.

In table 1 are shown the results obtained on 14 samples of butter[6] from sweet cream made at the experimental creamery of the Dairy Division, Bureau of Animal Industry, of this Department, at Grove City, Pennsylvania. Samples of the regular run butter were sealed in 1 pound tins and sent to Washington, where the butter was scored and examined. For comparison with these results, table 1 also gives data on experimental samples made from a portion of the cream taken from the regular run and held until a slight acidity developed. These samples are marked "Bl", in each case. On each sample the volatile acids, without saponification, were determined as follows: To 50 grams of sample in a 500-cc. flask, such as used for the determination of nitrogen by the Kjeldahl method, 5 cc. of 25 per cent phosphoric acid and 100 cc. of boiled distilled water were added, and the mixture steam distilled at such a rate that 100 cc. of distillate were collected in ten minutes. Another determination of volatile acid was made, treating the sample as above, except that instead of steam distillation, the flame was applied directly to the 500-cc. flask and 100-cc. distilled over in thirty minutes. The distillate, in each case, was titrated to the phenolphthalein end point with tenth normal sodium hydroxide.

An inspection of table 1 shows that although there is scarcely any perceptible difference in the quality of the butter when fresh, as shown by the score, yet, in each case, there is an increase in volatile acids from the experimental samples over the amount found in the "regular run" butter from the same cream. In all cases, the results found by the direct distillation were higher than by the steam distillation, although practically the

[6] These same samples are included in the work by North and Reddish, Yeasts and Oidia in High-grade Experimental Butter, loc. cit.

TABLE 1

Showing results on fresh butter made at Grove City, 1920

SAMPLE NUMBER	ACIDITY OF CREAM	BUTTER SCORE AT FACTORY	VOLATILE ACIDS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS		OXIDIZABILITY VALUE	LACTOSE
			Steam distillation	Direct distillation		
						per cent
200 B	0.17	93	0.2	0.4	0.4	0.41
201 B	0.16	94	0.3	0.8	0	0.44
202 B	0.16	94	0.2	0.4	0	0.36
203 B	0.16	94	0.2	0.4	0	0.39
204 B	0.17	94	0.2	0.6	2.2	0.34
205 B	0.17	94	0.2	0.4	0	0.37
205 B1	0.40	94	0.7	1.6	1.9	0.35
206 B	0.16	94	0.3	0.4	1.4	0.37
207 B	0.16	94	0.2	0.4	1.3	0.34
207 B1	0.24	94	0.5	0.6	2.5	0.46
208 B	0.16	94	0.4	0.8		0.35
208 B1	0.25	93	0.5	1.1	1.5	0.36
210 B	0.16	94	0.2	0.4	1.7	0.36
210 B1	0.29	94	0.3	0.6	1.3	0.35
211 B	0.17	94	0.2	0.4	1.6	0.36
211 B1	0.23	93	0.3	0.6	1.2	0.26
213 B	0.15	94	0.2	0.5	1.6	–
213 B1	0.31	94	0.4	0.8	0.6	0.31
214 B	0.16	94	0.3	0.5	0.9	0.34
214 B1	0.30	94	0.4	0.7	0.6	0.37
215 B	0.17	94	0.2	0.4	0	0.31
215 B1	0.27	93	0.4	0.6	0	0.35
Sweet cream butters—"B:"						
Maximum			0.4	0.8	2.2	0.44
Minimum			0.2	0.4	0	0.31
Mean			0.2	0.5	0.9	0.36
Experimental butters—"B1:"						
Maximum			0.7	1.6	2.5	0.46
Minimum			0.3	0.6	0	0.26
Mean			0.4	0.8	1.2	0.35

Samples 209 and 212 were yeast experiments and hence not included in this table.

same difference between different samples is found by each procedure. The oxidizability value on the sweet cream butter varied from 0 to 2.2, and, on the experimental butter in table 1,

from 0 to 2.5, the difference not being appreciable, since the experimental error was generally about 0.5.

Table 2 shows the results obtained on duplicate portions of butters examined in table 1, after being held in cold storage at 22°F. for five to six months and again followed by holding in the

TABLE 2

Showing results on butters made at Grove City, 1920, and held in storage

SAMPLE NUMBER	FIVE TO SIX MONTHS IN STORAGE AT 22°F.				SIX TO SEVEN MONTHS IN STORAGE AT 22°F., THEN IN ICE BOX TWO WEEKS			
	SCORE	Volatile acids cubic centimeters of N/10 per 100 grams		OXIDIZABILITY VALUE	SCORE	Volatile acids cubic centimeters of N/10 per 100 grams		OXIDIZABILITY VALUE
		Steam	Direct			Steam	Direct	
200 B	94	0.5	0.5	0.7	92	0.2	0.6	2.0
201 B	93½	0.4	0.6	0	91½	0.4	0.7	1.2
202 B	92	0.6	0.7	0.9	92½		0.8	1.2
203 B	93	0.2	0.7	0.6	92		0.6	0.6
204 B	93	0.5	0.5	0.6				
205 B	93	0.4	0.5	1.0	91	0.5	0.6	2.0
205 B1	91	1.2	2.1	1.5				
206 B	92	0.4	0.6	1.4	88	0.5	0.7	1.3
207 B	93	0.3		0.6	88		0.8	1.4
207 B1	91½	0.6	1.2	1.2				
208 B	93	0.6	0.8	0.2	89		1.0	1.0
208 B1	93	0.5	1.4	0.2	86	0.6	1.0	1.4
210 B	93	0.4	0.6	*4.1	93		0.6	2.9
210 B1	93	0.4	1.0	1.9	90	0.4	0.9	3.2
211 B	93	0.3	0.7	1.6				
211 B1	93	0.4	1.2	2.7				
213 B	93	0.4	0.9	0.6				
213 B1	93	0.4	1.3	1.2	88	0.8	1.2	1.0
214 B	93	0.3	1.0	1.8				
214 B1	93	0.5	1.7	0.6	91	0.5	0.8	1.2
215 B	92½	0.2		0	91		0.9	1.0
215 B1	92	0.4	2.2	0.3				

* Exceptionally high, may be due to experimental error.

ice box two weeks to approximate the conditions of retail distribution. By comparing the sweet cream butter with the experimental butter in table 2, it is seen that, in general, after storage there is the same difference that was found when the

samples were fresh. The score on these butters, after being kept at the temperature of an ordinary ice box for two weeks, was generally somewhat lower than when the butters were first taken from cold storage. However, there was not a corresponding significant increase in volatile acids.

TABLE 3

Résumé of results from tables 1 and 2 showing changes during storage

		Volatile acids cubic centimeters of N/10 per 100 grams		Oxidizability value
		Steam	Direct	
Sweet cream butters				
Maximum	Fresh	0.4	0.8	2.2
	Storage	0.6	1.0	*4.1
	Ice box	0.5	1.0	2.9
Minimum	Fresh	0.2	0.4	0
	Storage	0.2	0.5	0
	Ice box	0.2	0.6	0.6
Mean	Fresh	0.2	0.5	0.9
	Storage	0.4	0.7	1.0
	Ice box	0.4	0.8	1.4
Experimental butters				
Maximum	Fresh	0.7	1.6	2.5
	Storage	1.2	2.2	2.7
	Ice box	0.8	1.2	3.2
Minimum	Fresh	0.3	0.6	0
	Storage	0.4	1.0	0.2
	Ice box	0.4	0.8	1.0
Mean	Fresh	0.4	0.8	1.2
	Storage	0.6	1.5	1.2
	Ice box	0.6	1.0	1.7

* See footnote table 2.

Table 3 shows the maximum, minimum and average values found on the sweet cream butter and the experimental butter when fresh and after the two periods of storage. There is a slight but noticeable increase on both the sweet cream butter

TABLE 4

Showing results on experimental butters made at Grove City, 1920

NUMBER	ACIDITY OF CREAM	TIME WHEN ANALIZED	SCORE WHEN ANALIZED	VOLATILE ACIDS AS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS: Steam distillation	VOLATILE ACIDS AS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS: Direct distillation	OXIDIZABILITY VALUE	LACTOSE
							per cent
217 B1	0.35	Fresh	91	0.5	1.1	0.4	0.29
		Storage	92½	0.8	2.4	1.6	
		Ice box	86		2.2	1.5	
218 B1	0.45	Fresh	91	0.6	1.3	1.8	
		Storage	92½	0.7	2.2	2.4	0.30
		Ice box	87		1.9	1.0	
221 B1	0.51	Fresh	92	0.6	1.3	1.4	0.27
		Storage	92	0.8	1.6	1.7	
		Ice box	89		1.8	0.4	
222 B1	0.55	Fresh	92	0.6	1.3	0.9	
		Storage	93	0.8	1.4	0.9	0.21
		Ice box	89		1.7	1.0	
220 B1	0.58	Fresh	92	0.6	1.5	1.3	0.21
		Storage	93	0.7	1.4	1.1	
		Ice box	86	1.2	1.7	1.4	
216 B1	0.60	Fresh	90	0.7	1.4	0.5	0.27
		Storage	93	0.8	1.6	2.1	
		Ice box	91	1.0	1.5	1.2	
225 B1	0.60	Fresh	90½	0.9	1.5	1.3	0.28
		Storage	92	1.1	1.3	0.9	
		Ice box	89		2.0	0.3	
226 B1	0.62	Fresh	92	0.8	1.6	1.0	0.21
		Storage	92	1.1	1.7	0.6	
		Ice box	89		2.5	2.1	
228 B1	0.63	Fresh	91	0.7	1.3	0.6	
		Storage	92	1.0	1.7	0.6	0.19
		Ice box	89		2.2	1.0	
224 B1	0.65	Fresh	91	0.8	1.5	2.9	
		Storage	92	1.0	2.1	3.0	0.22
		Ice box	88		2.5	0.9	

TABLE 4—*Continued*

NUMBER	ACIDITY OF CREAM	TIME WHEN ANALYZED	SCORE WHEN ANALYZED	VOLATILE ACIDS AS CUBIC CENTIMETERS OF N/10 PER 100 GRAMS		OXIDIZABILITY VALUE	LACTOSE
				Steam distillation	Direct distillation		
							per cent
219 B1	0 67	Fresh	92	0 8	1 4	1 1	0 35
		Storage	93	1 0	2 4	1.6	
		Ice box	91½	1 1	1 6	0 9	
227 B1	0 67	Fresh	91	0 8	1.5	0.6	0 23
		Storage	92	0 8	1 5	0 3	
		Ice box	89		2 3	1 5	
Average		Fresh		0 7	1 4	1 2	0.25
		Storage		0 9	1 8	1 4	
		Ice box		1.1	2 0	1.1	

Cream 223 was held a greater length of time and not included in this table.

and the experimental butter during storage, the sweet cream butter showing a value, after six to seven months in cold storage and two weeks in the ice box, about equal to that of the fresh butter made from cream in which a slight amount of acidity had developed before churning. The maximum oxidizability value found at any time on the sweet cream butter was 4.1 and 3.2 on the above experimental butters. The next to the highest result on sweet cream butter was 2.9, the higher figure being possibly due to experimental error.

Table 4 shows the results obtained on twelve samples of butter made at Grove City from portions of cream which had been held from a few hours to twenty-four hours until the acidity noted in the table had developed, when it was reduced with milk of lime to approximately 0.25 per cent and the cream pasteurized and churned. In each case, the cream appeared to have a clean acid flavor. In six of the samples, the yeast count (microscopic) did not exceed 5000 per cubic centimeter in the cream when ready to churn; six showed counts varying from 10,000 to 30,000 yeasts and all of the samples showed less than 5000 oidia. The volatile acid figures on these samples were generally slightly higher than found on the experimental butters in table 1, made

TABLE 5

Showing volatile acid determination on cream and butter analyzed in Denver Laboratory, 1919

SAMPLE NUMBER	GRADE OF CREAM	ACIDITY OF CREAM, PER CENT LACTIC ACID	SCORE OF BUTTER	VOLATILE ACIDS, DIRECT DISTILLATION			
				Cubic centimeters N/10 per 100 grams		On water basis	
				Cream	Butter	Cream	Butter
1	Slightly sour, medium weedy	0.58	91.75	6.4	2 2	11.3	14.5
	Pasteurized		92 0	5.4	1 6	9.7	11.8
	Starter added		91 25	6 2	2.0	10.2	11.6
2	Slightly sour, medium weedy	0.61	91.5	6.4	1.4	9.4	9.7
	Pasteurized		92.75	5.8	1.6	8.8	12.1
	Starter added		92.5	7.0	1.8	9.9	11.3
3	Medium sour and vinegary	0.99	87.75	7.0	3.8	12.2	20.3
	Pasteurized		87.75	5.2	3.4	9.1	23.7
	Starter added		88.5	7.0	2.2	11.4	12.1
	Neutralized		89.0	6 4	2.2	10.5	14.3
	Neutralized and pasteurized		89.5	8.4	1 8	13.7	11.8
	Neutralized, pasteurized, and starter added		90.5	8 6	1.5	13.4	10.1
4	Sour, medium vinegary, slightly stale	1.07	87.0	6.1	2 2	9.5	13.7
	Pasteurized		86.75	5 2	2.1	8.2	15.3
	Starter added		88.0	6.4	2.1	9.6	14.7
	Neutralized		88.25	7.6	2 2	11.6	13.2
	Neutralized and pasteurized		88.25	6 3	1.9	9.7	12.5
	Neutralized, pasteurized, and starter added		89.5	7.6	1.6	11.3	9.7

5	Actively boiling, medium yeasty and vinegary, slightly stale	1 26	87 0	7.2	2.6	12.4	10.5
	Pasteurized		87 0	6.6	3.0	11.5	10.9
	Starter added		88 0	7.0	1.8	11.5	9.1
	Neutralized		88.5	6.6	2.0	11.1	11.7
	Neutralized and pasteurized		88 5	6 5	2.8	10.9	18.3
	Neutralized, pasteurized, and starter added		89.5	9.4	4 6	—	26.9
6	Foamy, high acid, medium vinegary, stale, bitter, slightly cheesy	1 53	87 5	7.2	22.	11.0	12.9
	Pasteurized		86.0	5 4	1 8	8 4	9.9
	Starter added		87.0	6 6	2.4	9 8	13.1
	Neutralized		85 25	7.2	2.7	12.4	14.8
	Neutralized and pasteurized		86 0	13 6	3 5	20 5	23.7
	Neutralized, pasteurized, and starter added		86 5	7 6	3 7	11.0	28.5
7	High acid, high vinegary, medium stale, cheesy and rancid, slightly bitter	1.35	84 25	8.4	2 9	12.7	9.1
	Pasteurized		86.75	4 8	1.6	7.5	9.3
	Starter added		87.25	5 8	1.8	8 8	9.5
	Neutralized		88.0	9 0	3.2	13.2	14.4
	Neutralized and pasteurized		88 0	8.0	6.6	11.8	41.4
	Neutralized, pasteurized, and starter added		88.5	10.2	3 6	14.6	18.3
8	High vinegary, rancid, bitter, stale, slightly greasy and cheesy	1 25	85.25	6.7	2.2	11.0	12.8
	Pasteurized		84.5	6.4	2.0	12.1	12.6
	Starter added		83 5	9.4	2.8	16.1	14.6
	Neutralized		86.75	7.2	2.2	13.9	12.0
	Neutralized and pasteurized		86.0	8.8	2.0	16.4	10.2
	Neutralized, pasteurized, and starter added		87.0	9.0	2.0	15.9	14.7

TABLE 6

Results on cream and butter analyzed at Denver Laboratory, 1918

NUMBER	GRADE OF CREAM	CREAM				BUTTER	
		Microscopic count		Oxidizability value	Volatile acids as cubic centimeters, N/10 per 100 grams sample Steam distillation	Oxidizability value	Volatile acids as cubic centimeters, N/10 per 100 grams. Steam distillation
		Yeasts	Oidia				
C 23	Sweet, raw	2,600,000*	−100,000	1.6	0.6		
C 14	Sweet, raw	200,000	−100,000	3.0	0.6		
C 16	C 15 and starter	−100,000	−100,000	4.1	0.7	2.4	0.4
C 24	C 23 and starter	600,000	−100,000	4.1	1.3	0.6	0.4
C 26	C 25 neutralized, pasteurized, and starter	260,000	−100,000	4.5	0.3	2.7	0.5
C 7	Composite "first grade"	600,000	300,000	4.6	2.3		
C 25	Sour, raw, part C 24	260,000	1,000,000	5.6	2.4		
C 12	Composite "first grade"	900,000	160,000	6.0	2.2		
C 32	Sour, clear flavor,	365,000†	18,000†	6.4	2.0		
C 15	C 14, pasteurized	800,000	−100,000	7.0	0.6		
C 4	Very bitter	300,000	300,000	7.1	2.8		
C 19	C 18, pasteurized	−100,000	400,000	7.9			
C 20	C 19 and starter	−100,000	540,000	9.4		4.1	0.4
C 18	C 17, neutralized			9.7			
C 17	Sour, raw, other half of C 14	−100,000	200,000	10.1	3.1		
C 21	Composite "first grade"	−100,000	−100,000	13.8	2.7	4.9	0.7
C 5	Slightly rancid	1,710,000	1,320,000	17.9	13.0		
C 34	Stale and cheesy	5,000,000†	2,400,000†	18.5	3.7		
C 28	C 27, pasteurized	6,400,000	600,000	27.0		6.8	1.8
C 31	Sour, greasy flavor	2,000,000†	*24,500	28.6	3.1		

C 10	Composite "first grade".............	1,000,000	600,000	29.3	3.3		
C 8	Very stale, slightly yeasty......	1,200,000	240,000	29.8	6.5		
C 3	Sour, clean flavored....	1,080,000	660,000	30.2	2.9		
C 6	Vinegary, high acid........	3,720,000	1,440,000	34.3	2.6		
C 9	Very cheesy and thick....	540,000	720,000	40.9	53.4		
C 22	"Second grade"...........................	600,000	400,000	41.1	1.7	7.5	0.6
C 13	Sour, "Second grade"........	8,200,000	600,000	43.2	3.8		
C 27	Sour, raw "second grade".	4,600,000	800,000	43.4	5.7		
C 33	Rancid and slightly yeasty...	1,700,000†	240,000†	44.1	11.5		
C 2	Very stale......	4,200,000	300,000	47.3	6.2		
C 29	Yeasty, had foamed very badly..........	12,800,000	260,000	62.0	3.4		
C 11	Too poor to use for buttermaking........ ...	18,480,000	2,100,000	70.3	3.6		
C 1	Very yeasty............	5,760,000	120,000	71.7	3.3		
C 30	Very high acid...........	4,600,000†	390,000†	78.2	3.6		

* This result is out of line and H. W. R. who had charge of the work suggests that it probably is an error.

† These are not microscopic counts but are viable counts per cubic centimeter of cream on wort agar incubated five days at 30°C.

TABLE 7

Showing results on experimental butters made at Grove City, 1920

NUMBER	CREAM HELD		YEASTS, MICROSCOPIC COUNT		TYPE YEAST	BUTTER SCORE	OXIDIZABILITY VALUE	VOLATILE ACIDS AS CUBIC CENTIMETERS N/10 PER 100 GRAMS		LACTOSE
	Days	Temperature	Cream	Butter				Steam	Direct	
										per cent
234 B5	3	Room	190,000	20,000	Inert	88	0.3	0.8	1.5	0.21
Storage				25,000		91	4.3	1.0	1.5	
Ice box				30,000		90	0.3		1.7	
234 B1	3	Room	5,000	−5,000	Check, pasteurized cream	90	0 5	0.6	1.3	0.20
Storage				−5,000		91	0.6	0.6	1 0	
Ice box				−5,000		90½	0 6		1 7*	
234 B4	3	Room	4,150,000	1,210,000	Dextrose fermenting	89	0.6	0.6	2.0	0.26
Storage				40,000		91½	1.8	0.7	1.3	
Ice box				140,000		91	1.5		1 8	
229 B2	5	10°	30,000	−5,000	Raw cream	92	0 8	0.6	1 3	0.21
Storage				180,000		91	1.2	0.7	1.3	
Ice box				165,000		89*	2.0	0.9	1.6	
233 B1	2	25–30°	−5,000	−5,000	Check, pasteurized cream	92	0.9	0.5	1.1	0.20
Storage				−5,000		91	0 3	0.7	1.4	
Ice box				−5,000		89	0.6		1.5*	
233 B2	2	25–30°	3,300,000	920,000	Lactose fermenting pasteurized cream	89	0.9	1.6	2.7	0.19
Storage				575,000		87	1.5	1.7	3.0	
Ice box				450,000		87*	0.7		3.4*	

209 B3.......	3	30–36°	790,000	35,000	Largely inert, raw cream neutralized and pasteurized	89	2.2	0.8	1.6	0.20
Storage......				500,000		88	1.7	1.3	2.2	
Ice box......				280,000		86	1.3	1.5	2.2	
209 B2.......	3	35°	12,820,000	5,220,000	Torulas phaerila, lactose splitting	91	4.8	0.9	1.5	0.20
Storage......				5,140,000		89	5.4	1 2	1 9	
Ice box......										
212 B2.......	5	25–30°	14,000,000	7,725,000	Lactose splitting	86	6.6	0.4	1.2	0.08
Storage......	2	10°		12,475,000		90	9.1	0.6	1.5	
Ice box......				3,140,000		83	10 1	0.6	1.4	
209 B1.......	7	20°	19,400,000	13,300,000	Torula sphaerila, lactose splitting	86	10 2	0.7	1 6	0.13
Storage......				9,780,000		88	11.0	1 1	1.6	
Ice box......				1,680,000		87	7.7	1 0	1.8	
234 B3.......	3	Room	11,100,000	3,650,000	Torula creamonis, lactose splitting	88	10 4	1 6	2.5	0.11
Storage......				1,650,000		87	8.1	1.6	3.4	
Ice box......				3,300,000		86	7 7	2.5	3.8	
234 B2.......	3	Room	14,500,000	5,600,000	Tortula sphaerila, lactose splitting	87	10 7	1 0	2.1	0.10
Storage......				8,900,000		85	9.7	1 0	2 5	
Ice box......				5,200,000		87*	9 0		2.5*	
212 B1.......	5	25–30°	13,000,000	18,300,000	Lactose splitting	86	15.3	0.7	1.4	0.04
Storage......				14,450,000		89	19.6	0.5	1.7	
Ice box......				3,500,000		87	24.4	0.8	1.6	

* These samples were not put in ice box before analyses.

from cream containing a slight amount of acidity which was not reduced before pasteurization and churning. The oxidizability value showed practically no change during the two periods of storage, all values being lower than found on the sweet cream butters in table 1.

Table 5 shows the volatile acid determination and score on butter made from cream received at a commercial creamery at Denver during the summer of 1919. It is seen that the volatile acid determination on these butters is higher, in every case, than that given for the butter made from sweet cream at Grove City, but is approached by the experimental butter from slightly soured cream. Columns 7 and 8 in table 5 show the volatile acids on cream and the corresponding butters calculated to a water basis. These results are greater on the butter in 30 cases and less in 10. It is evident that although the butter may contain some wash water, in addition to the water from the buttermilk, there is a greater proportion of volatile acids to water in the butter than in the cream, in the majority of cases. This may be explained by the fact that volatile acids may be dissolved in the fat as well as in the aqueous portions of the cream.

In table 6 are shown the microscopic count of yeasts, the oxidizability value and volatile acid determinations on samples of cream secured from the above mentioned creamery at Denver in 1918. The samples are arranged according to ascending oxidizability values. There is seen to be some agreement between the count of yeasts and the oxidizability value, both determinations being higher on the poorer samples. The volatile acids are also generally higher on the samples that show greater physical signs of decomposition.

Seven samples of butter were made from portions of the above cream and the oxidizability value and volatile acid figure are shown in columns 7 and 8 of the same table. There is a noticeable lower oxidizability value and volatile acid figure on the butter than on the corresponding cream. It is evident that a greater portion of the volatile acids and the oxidizable substances are removed from the cream during the process of buttermaking, although more remain in the butter from cream showing

higher amounts than in butter from cream showing lower volatile acids and oxidizability value.

In order to understand more fully the significance of yeasts in cream and butter, portions of the regular run cream received at the Grove City Creamery were inoculated with different types of yeasts which originally were isolated from foamy or stale cream. The cream was held at given temperatures for three to five days, then churned in the experimental room of the creamery and the butter sealed in cans and sent to Washington for analysis. Samples of raw cream and pasteurized cream that were not inoculated were held and churned under the same conditions to serve as checks on the yeast experiments. The results are shown in table 7. Each sample was examined when fresh, after five to six months in storage and after six to seven months in storage and two weeks in the ice box. The samples are arranged in order of ascending oxidizability values when fresh. It is seen that there is a rather definite relation between the lactose splitting yeasts and the oxidizability value, the latter being high and the lactose very low, on the samples of butter made from cream which contained the higher numbers of lactose splitting yeasts.

CONCLUSIONS

The volatile acids in 14 samples of commercial sweet cream butter scoring 93 to 94, was found to be 0.2 to 0.4 and 0.5 to 0.8 cc. N/10 per 100 gram sample as determined by the two methods of procedure used in this work. The score on these butters, after being kept in cold storage five to six months, was, in general, about one point lower than when they were fresh and the volatile acid figure was about twice as large. After six to seven months, the butters were removed from cold storage and kept at about 15° for two weeks, this causing a decided drop in score but, however, no corresponding significant increase in volatile acids.

It has been found that there is a noticeable difference between the amount of volatile acids found in the sweet cream butter and the amount found in butter made from clean acid cream, the acidity of which had been reduced before pasteurization. In these experiments, an oxidizability value on butter greater than 5, indicated that the butter was made from cream which had contained a large number of lactose splitting yeasts.

THE VALUE OF A TITRATION TEST FOR ACIDITY AT THE RECEIVING PLATFORM

R. S. FLEMING AND J. H. NAIR

Research Laboratories, Merrell-Soule Company, Syracuse, New York

Recently the maintenance of an acidity standard for fresh milk by condenseries and powdered milk manufacturers has been the object of adverse criticism, based on the established fact that any titration test applied to milk fresh from the cow will indicate an apparent acid condition, which cannot be due to lactic acid, the cause of sour or curdled milk, since the presence of this acid indicates bactericidal action on the milk sugar, a process requiring a lapse of more or less time, according to conditions. Brew (1) has pointed out that this apparent acidity may be as high as 0.25 per cent and yet the milk be processed successfully, though his evidence on that score is negative. Sommers and Hart (2) found in one herd variations on titrable acidity of 0.102 to 0.257 per cent, 52 per cent being above 0.18 per cent, and showed that this bears no relation to the heat coagulation of milk. McInerney (3) found one herd of five cows varying from 0.175 to 0.205 per cent acidity with a composite of 0.19 per cent, and in another mixed herd averages of 0.123 to 0.18 per cent according to breed, with milk from individual cows as high as 0.22 per cent. Van Dam (4) holds that titrating milk leads to wrong conclusions as this measures "potential" acidity, while hydrogenion methods measure the "actual" acidity. Henkel (5), in 10,000 determinations on the milk of individual cows, found variations of 0.1375 to 0.225 per cent, though mixed herd milk had much narrower limits. Baragiola (6) emphasizes the necessity of differentiating between the degree of acidity or concentration of the hydrogenion, expressed in millimoles per liter, and the acid content (total acid, titrable acid, or acid value), expressed in cubic centimeters of normal solution or grams of lactic acid per liter.

The cause of the acid reaction of fresh milk to phenolphthalein has been the object of much investigation, which has resulted in narrowing down the probabilities to two or three sources, or a combination of them. Van Slyke and Bosworth (7) have presented good evidence to substantiate their theory that the apparent acidity is due to the acid phosphates present. Richmond (8) attributes it partly to acid phosphates and partly to dissolved carbon dioxide, though Van Slyke and Baker (9), on the contrary, found that the degree of acidity, as measured by titration tends to decrease with increasing CO_2 content, a condition which Baker and Breed (10) believe is due to the entrance of bicarbonate from the blood of the cow. Bordas and Touplain (11) investigated the titrable acidity, with phenolphthalein, of milk serum, the coagulum containing the insoluble salts, the casein plus the insoluble salts, and the pure casein separated by the alcoholic method. They concluded that the original acidity is due to casein and that no free acid or acid salts exist in milk at the outset. Bordas (12) made further studies and reported that the increase in acidity is due to casein liberated from combination with calcium by the formation of calcium lactate.

This conflicting evidence as to the cause of titrable acidity in fresh milk is of less importance from the standpoint of factory practice than the question of the justice of an acid standard to the factory patrons. If it is true that any considerable number of cows or any one breed of cattle consistently give milk which has a higher titrable acidity than the standard maintained or if the acid test fai's to measure the quality of the milk at the receiving platform, the contention of Brew, Hart and others that manufacturers of milk products are in error in maintaining a rejection test based on titrable acidity must be acknowledged and every effort bent toward development of some other test which may distinguish poor milk with more certainty and yet be as rapid of manipulation, as the titration method. Up to the present time no substitute has been devised which meets the latter requirement, the vital one from the manufacturing standpoint. This being the status of the question, the attention of this laboratory was turned to an investigation of the titrable acidity of individual cows and of herds.

The practical experience of a number of milk inspectors was reviewed at the outset and the gleanings summarized into three pertinent facts. First, that the average acidity of herd composite milk as received at the factory was wel below 0.18 per cent, though it was probably true that individual cows of certain herds or breeds gave milk higher than that in acidity. Second, that milk was not rejected on the basis of titrable acidity alone, for an acid test was resorted to only when the odor and flavor of the milk suggested to the experienced inspector that it was questionable. In other words, the acid test is applied mainly as an adjunct to the senses of the trained inspector. This is in line with the best practice of the day. As Hunziker (13) states:

> Experience has shown that, while it is necessary for the condenseries to decide on a maximum acidity of milk above which all milk be rejected, the nose and the palate of the experienced inspector are better criterions than the acid test alone, as to the fitness of milk for condensing. Acid tests are valuable in the case of uncertainty and suspicion as to the quality of any given can of milk. . . . . What has been stated concerning the necessity of high quality of fresh milk in the successful manufacture of condensed milk is equally true in the manufacture of milkpowder. . . It is especially essential that it arrive at the factory perfectly sweet, since acidity tends to lower the solubility of the finished product.

This has been confirmed by our own experience during the past twelve years, during which approximately 10,000,000 cans of milk have been taken in at our receiving platforms. During the flush of the past season an average of 12,000 cans were handled daily, with complete freedom from curdled milk or sour cream. Third, our wide experience has demonstrated clearly that it is impossible to manufacture a heavy cream of less than 0.09 to 0.095 per cent acid or a light cream of less than 0.11 to 0.115 per cent from milk testing 0.17 per cent at the receiving room. Before this fact had been established thousands of pounds of fresh cream became sour during transportation to market. This shipping quality of the fresh cream is an important item. It has been repeatedly demonstrated that heavy cream of 0.10 per cent or a light cream of 0.12 per cent acid may

be apparently in excellent shape when it leaves the factory, but it invariably sours, more quickly in the warm months, before it reaches the retail customer. To insure a cream that will stand up in such shape as to meet the exact demands of the trade, it is essential that the milk as received at the factory be below 0.17 per cent titrable acid. More important, probably, than the souring of this fresh cream is the high acid flavor and the greater tendency toward curdling which appears in milk powdered from fluid milk of high acidity. Maintaining an uniformly high standard of quality in powdered milk means efforts beginning at the farm and this necessitates constant supervision of production conditions. The acid titration test provides one method of checking up on these, as any marked bacterial growth or lack of proper cooling is reflected in increased acidity. Long experience has shown that high acid milk taken in at the receiving platform continues to develop acidity so rapidly that milk powder dried from it has a peculiarly disagreeable acid flavor and, when used for cooking, will curdle easily.

To ascertain definite facts concerning the apparent or titrable acidity of fresh milk and of milk at the receiving stand, a series of investigations were carried on by the department during the year of 1920. Herds in seven different territories in western New York and Pennsylvania were tested during the months of January, March, July, September and October. For the most part the cattle were mixed, with Holstein, Guernsey and Jersey the predominant breeds. In one territory practically all of the cows were Jerseys and in another mostly Holsteins. A total of 766 herds were tested.

The initial work was done on the milk of individual cows, the first titration being run at the farm immediately upon the completion of each milking. Marshall's method (14) was used, the 0.1 N alkali having been carefully prepared and standardized against standard N/5 HCl, previously tested by precipitation with $AgNO_3$ and ignition. The milk was allowed to stand for a few minutes after being drawn to allow the froth to subside, a 9 cc. sample being then withdrawn with a pipette and placed in a white china cup. Titration was made with 3 or 4 drops of

1.25 per cent phenolphthalein, with no added water, with 9 cc. of added water and with 18 cc. of added water. Sufficient tests were run to determine that the addition of water did not affect the titration value expect to make the end point more easily visible. Alkali was added till a faint pink, permanent for one minute, was apparent. The milk from each cow was next strained into a can through filter cloth and a pint sample placed in a sterilized, glass-stoppered bottle. Upon the completion of the whole milking these jars were cooled and taken to the factory, where the development of acidity was followed closely Titrations were made at the end of 16, 20, 24, 40, 44, 47, 50 and 60 hours, souring being induced in one series by elevating the temperature at the end of forty-four hours from 54° to 72°. The effect of pasteurization on the acidity of the milk was tried. In one series this was done at the end of twenty-four hours by raising the temperature to 145° for thirty minutes. The samples were in glass-stoppered jars, giving no outlet for any volatile gas, to which may be due the average increase of 0.005 to 0.01 per cent in the acidity of this series. In another group pasteurization was carried out in open glass jars after forty-eight hours in a similar manner. Here there was a decrease in acidity of as much as 0.055 per cent in one case and an average decrease of 0.015 per cent.

Since measurements of the acidity of milk from individual cows indicated no unusually high values attention was turned to an investigation of mixed herd milk as received at the factory. The method used was to mix the milk in each can, as received, with a dipper and then to take an aliquot sample from each can of the milk brought in from any one herd, the whole being mixed to give a herd composite. These samples were placed in sterilized glass-stoppered jars and determinations made as soon as possible. Ordinarily double titrations were made with 9 cc. of milk and 18 cc. of water with occasional check runs with no added water. In all cases where the milk showed 0.17 per cent or higher acid an investigation was made of any conditions which might have been responsible for it and a check-up was run on the fresh milk from the individual members of the herd at the farm. In order

to ascertain whether high acid corresponded with high solids not fat, as contended by some observers, the current ten-day butterfat test of each herd as regularly run in the factory was recorded and used as a criterion, since high butterfat usually accompanies high solids not fat.

In table 1a are given the results of tests on the individual milk of one group of cows. Temperatures of the samples at time of titration are recorded at the foot of each column. These cows were tested on January 29. Table 1b shows the results obtained from a second group of cows tested on March 26. The dates when the cows freshened are shown in column 2. Temperatures of samples are recorded as above.

Variations in acidity range from 0.10 to 0.175 per cent with an average of 0.136 per cent, ten being below and eight above that figure. The composite of the mixed milks is 0.145 and 0.14 per cent respectively. In six cases, cows 8, 9, 10, 11, 14 and 17, the acidity was lower after sixteen hours than when the milk was freshly drawn, a phenomenon previously observed by Koning. That there is some relation between acidity and the period of lactation is indicated by the fact that the cows that were farthest along, cows 11, 12, 14, 15 and 16, show the lowest acidities. The slow development of acidity when milk is quickly cooled and kept at low temperature is worthy of note. The results obtained are somewhat lower than the majority of those reported by other observers. In only one case, cow 7, would any of these milks have been rejected on a standard of 0.17 or 0.18 per cent and in neither case would the composite milk have been refused, the most important conservation from the standpoint of factory practice or of the producer.

In table 2 are given the results obtained on mixed herd milk in seven territories as received at the factory. Under each 0.005 per cent of acid are listed the number of herds showing that amount, with the average butterfat test of the group immediately below.

In checking up the herds where values higher than 0.165 were in recorded the following results were obtained. The one sample territory A was 0.36 per cent when tested and was curdled four

hours after being received. Of the two samples showing 0.17 in territory C, in both cases improper cooling in conjunction

TABLE 1

(*A*)

COW NUMBER	ACIDITY AT MILKING	AFTER 16 HOURS	AFTER 20 HOURS	AFTER 24 HOURS
	per cent	*per cent*	*per cent*	*per cent*
1	0 14	0.15	0 155	
2	0.10	0.125	0 115	
3	0.12	0.14	0.15	
7	0 11	0.15	0 13	
5	0.13	0.15	0 15	
6	0.115	0.135	0.135	
7	0.17	0.18	0.18	
8	0 13	0.12	0.125	
Composite of above..... ...	0 145	0.145	0 145	0.145
Temperature of above	70°F.	58°F.	57°F.	58°F.

(*B*)

COW NUMBER	WHEN FRESHENED	ACIDITY AT MILKING	AFTER 16 HOURS	AFTER 20 HOURS	AFTER 24 HOURS	AFTER 40 HOURS	AFTER 44 HOURS	AFTER 47 HOURS	AFTER 50 HOURS	AFTER 60 HOURS	CONDITION OF MILK
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	
9	February	0.17	0.15	0.155	0.16	0.155	0 155	0.155	0.155	0.20	Turning
10	January......	0.175	0.155	0.16	0.16	0.165	0.16	0.16	0.16	0.165	Sweet
11	September...	0.145	0.14	0 14	0.14	0 145	0.14	0.14	0.14	0.165	Turning
12	September...	0.135	0.135	0.14	0.14	0.14	0.14	0.14	0.14	0.32	Sour
13	January......	0.155	0.16	0.165	0.165	0.175	0.18	0.175	0.175	0.185	Turning
14	September...	0.11	0.105	0.115	0.115	0.155	0.115	0.115	0.115	0.15	Sweet
15	September...	0.12	0.125	0.125	0.13	0.13	0.13	0.13	0.13	0.14	Sweet
16	December....	0 125	0.14	0 13	0.135	0.135	0.135	0.135	0 135	0 175	Turning
17	January......	0.145	0 13	0.14	0.14	0.135	0.14	0.145	0.145	0.225	Sour
18	March	0.15	0.16	0.165	0.165	0.165	0.165	0.165	0.16	0.205	Turning
Composite of above..........		0.14	0.14	0.145	0.15	0.15	0.15	0.15	0.16	0.55	Sour
Temperature of above..........		70°F.	52°F.	53°F.	53°F.	54°F.	54°F.	72°F.	74°F.	76°F.	

with hot weather was found to be the cause. Tests made at the farm at milking time showed composits of 0.135 and 0.14 re-

spectively, with no individual cows of high acid. The one sample higher than 0.17 when received was composed of milk from two cans, one of which was rejected as sour after the sample had been mixed. Of the high acid herds in territory D, of which there are two, tests made at the farm showed an acidity on the composite of 0.15 per cent in one case. The other herd consisted of three cows, which gave fresh milk testing 0.15, 0.175 and 0.18 per cent respectively. The farmer was keeping the milk

TABLE 2

FACTORY	0 11	0 12	0 125	0 13	0 135	0 14	0 145	0 15	0.155	0 16	0 17	0 17-0 36
A			1	6	13	31	18	17				1
Average butterfat				3 46	3 65	3 52	3 55	3 72				
B	1		2	12	15	15	16	9				
Average butterfat	5 0		3 92	3 82	4 03	4 16	4 00	4 01				
C			5	11	31	41	37	43	28	2	2	1
Average butterfat			3 5	3 55	3 52	3 51	3 50	3.54	3 57	3 52	3 50	
D			1	22	18	25	12	14	2	6	1	1
Average butterfat			3 5	3 95	3 93	3 89	3 91	3 77	3 60	3 52	4.30	5 0
E	5	14		28		39		15		2	1	
Average butterfat	3 73	3.70		3.85		3 89		3.93		3 70	3 60	
F				14		42		20		18	5	
Average butterfat				3 71		3 74		3 83		3 93	3 82	
G	2	14		37		23		19		7		
Average butterfat	3 98	3 70		3 93		3 93		3 80		4 00		

from the first cow at home for his own use. The mixed milk of the other two cows gave a value of 0.18 per cent. This is an unusual condition. The only herd showing as high as 0.17 in territory E was tested first at the farm for a composite with 0.16 per cent acid apparent. A check-up made the following night on the milk from the individuals of the herd gave results as follows: 0.15, 0.15, 0.12, 0.11, 0.18, 0.16, 0.15, 0.10, 0.13, 0.16 and 0.18 per cent, an average of 0.145 per cent. In con-

nection with these results it may be mentioned that these tests being made in October when the pasture was very short, this farmer was feeding sweet corn to his cows just prior to milking. In territory F tests were made at the farm on the milk from the five herds showing 0.17 per cent acid at the factory. Composites taken at milking time gave 0.14, 0.14, 0.15, 0.16 and 0.17 per cent respectively. Conditions prevented tests on the individual cows of this last herd.

The average acidities in the various territories were: A—0.141, B—0.139, C—0.44, D—0.141, E—0.135, F—0.144, G—0.136 The average acidity of the 766 herds, using the values originally obtained at the factory and including the two cases where the milk was palpably sour, was 0.140 per cent. Examination of the butterfat contents and the deduced solids not fat of the various herds, territories and groups indicate that there is no consistent dependence of high acidity upon high solids-not-fat content. In fact, territory B, where the cattle are practically all Jerseys, was third from the lowest in average acidity and had no values higher than 0.15 per cent. Among the 766 herds examined only two showed conditions, existent in the cows themselves causing an apparent acidity of 0.17 per cent or higher, and one of these might have been eliminated had it been possible to make further tests. Stated differently, only 0.26 of one per cent of all the herds tested, representing 7700 cows, furnished milk which would have been rejected on the basis of an apparently high acid condition, provided the milk was properly and sanitarily handled. Where this was not done such a test proved of value in detecting milk which was improperly cooled or contaminated in some manner.

To summarize the results obtained we may say that the normal acidity of fresh milk of individual cows is from 0.14 to 0.145 per cent, that the normal acidity of composite herd milk as received at the factory is 0.140 per cent and that where milk is handled in a cleanly and careful manner it will not be rejected on the basis of any acid test now in use by the manufacturers of milk products. The value of the acid test in checking the methods of production is, accordingly, clearly demonstrated and

its ease of application combined with this demonstrated reliability warrants its use until such time as some other equally rapid and more dependable method of determining the quality of milk shall have been perfected. Granted that the acid test occasionally detects milks which naturally have an acidity higher than the standard, it must be admitted that such milk is abnormal and comes from abnormal cows. That the quality of this milk may or may not be poorer does not enter into the question Such milk is abnormal and no practical working scheme can allow for all abnormalities. Milk is occasionally found with butterfat or total solids content below the legal minimum, but who would argue therefrom that the standards maintained by Federal, State and Municipal authorities should be lowered? The percentage of cows and herds showing abnormally high acid is so small as to be negligible and the manufacturer is doing no injustice to the producer when he insists that all milk must be delivered with an acidity below 0.17 or 0.18 per cent, particularly when such a test is applied as an adjunct to the nose and palate of the experienced inspector.

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A MODERN CREAMERY OF THE MIDDLE WEST

J. E. COLONNA

East Pittsburg, Pennsylvania

That modern creameries are tending towards electrification is illustrated in the recent installation made throughout the large model plant of the Peoria Creamery Company of Peoria, Illinois.

The efficiency of electric motor drive hardly needs explanation in this electrical era. The neat, clean appearance of electrified creameries speak for themselves. Every machine has characteristics of its own with respect to continuous or intermittent service which in many cases is quite severe. Accordingly, the right motor is selected for the right kind of work—each machine suited to its exact needs.

The electrical equipment in this creamery, a photograph of which is shown in figure 1, consists in part, of a 100-horse power motor, illustrated in figure 2, for one 125-ton ice machine, and a 40-horse power motor for a 50-ton ice machine. The motors for these two machines operate continuously. Four rotating churns, as shown in figures 3 and 4, are each geared to a 5-horse power motor. Note the suitable splash-protection which has been provided for these motors. Figure 5 shows two pasteurizing machines which are operated by a 5-horse power motor.

Among the various other machines that are electrically operated and which one would expect to find in a modern plant of this kind, the freight elevator has not been excluded; but has also been assured of exceptionally smooth acceleration, by a 30-horse power elevator motor and control.

The advantages of electric drive are of vital interest to the creamery industry on account of the low operating cost, desirable working conditions and the quality and quantity of the resulting output.

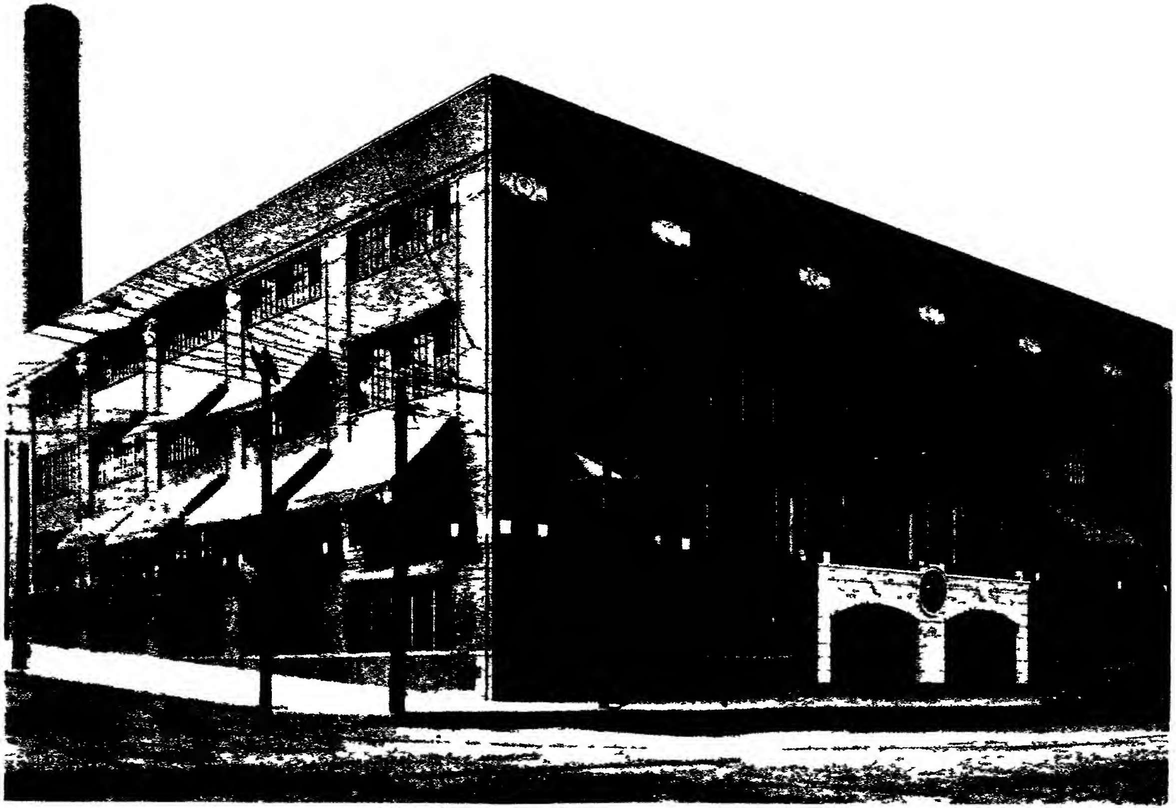

FIG 1 VIEW OF THE PEORIA CREAMERY COMPANY'S PLANT AT PEORIA, ILLINOIS

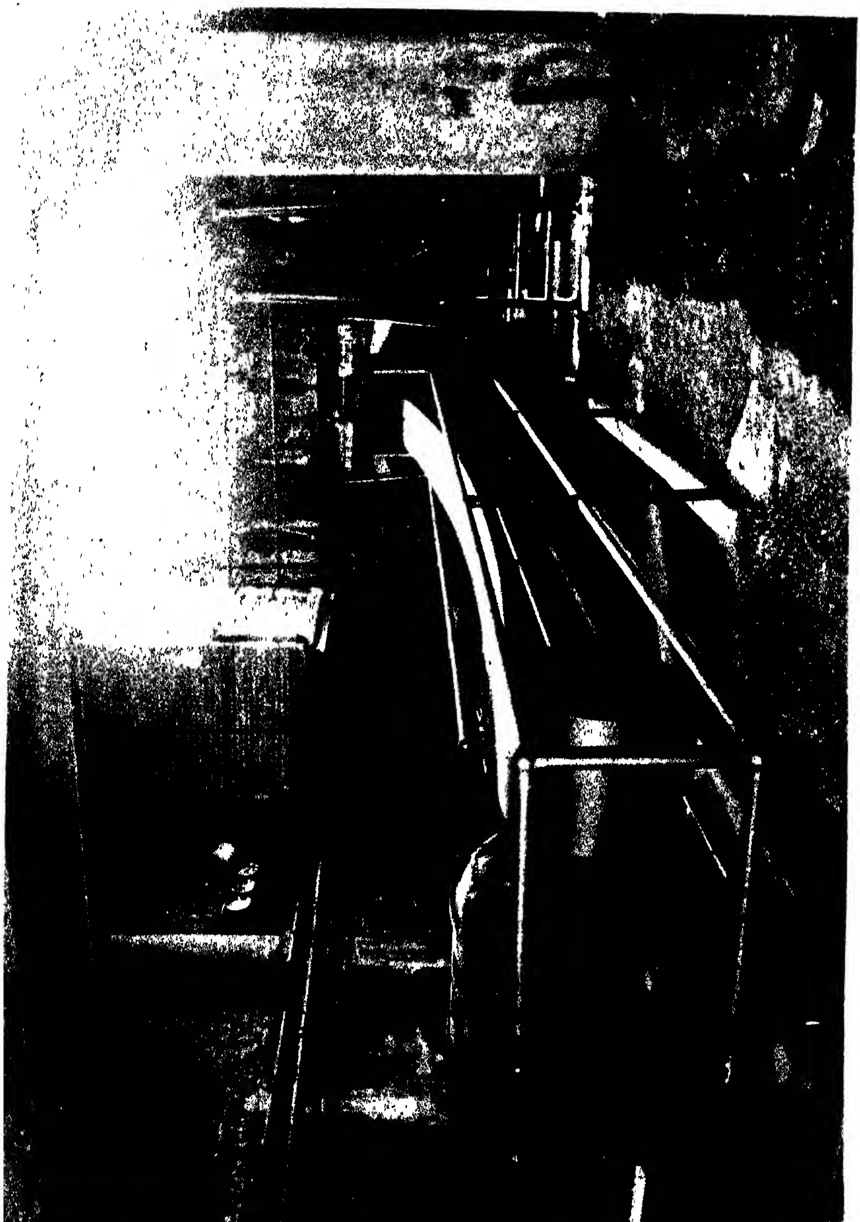

FIG. 2. 100-HORSE POWER MOTOR DRIVING 125-TON ICE MACHINE

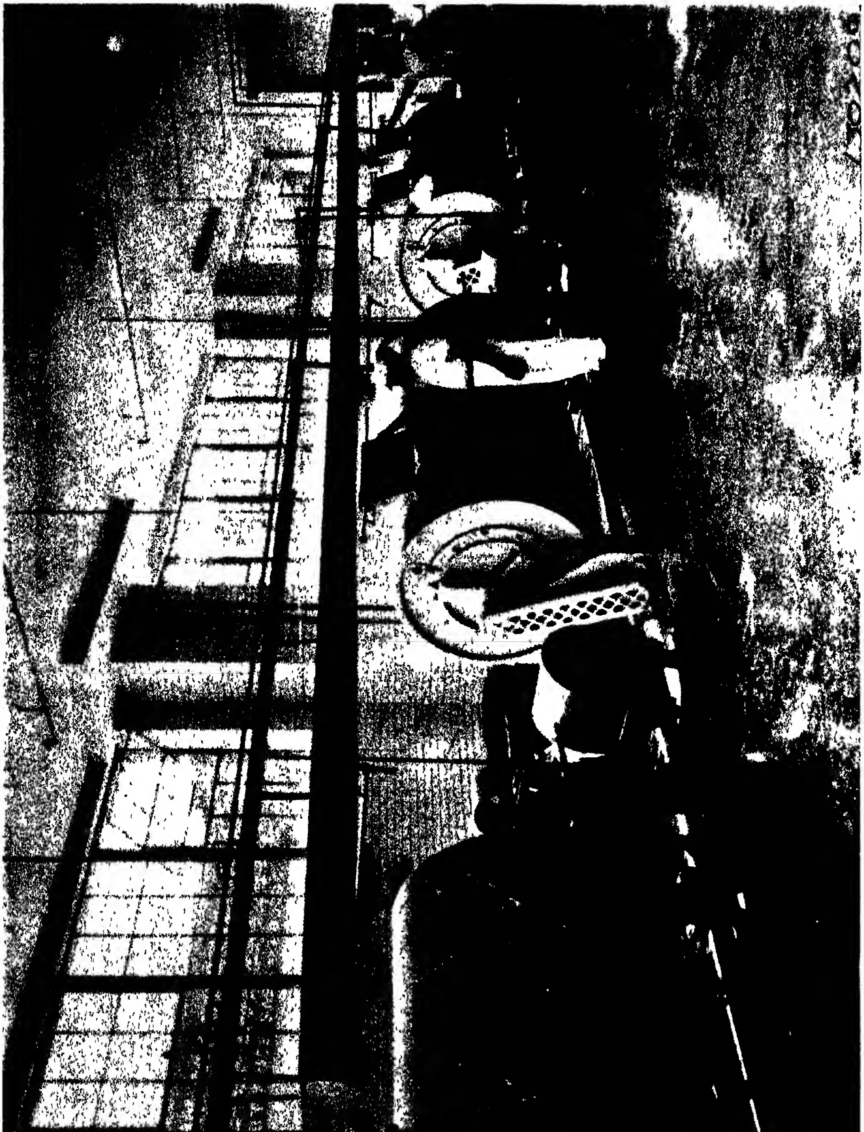

Fig. 3. Rotating Churns Each Driven by a 5-Horse Power Motor

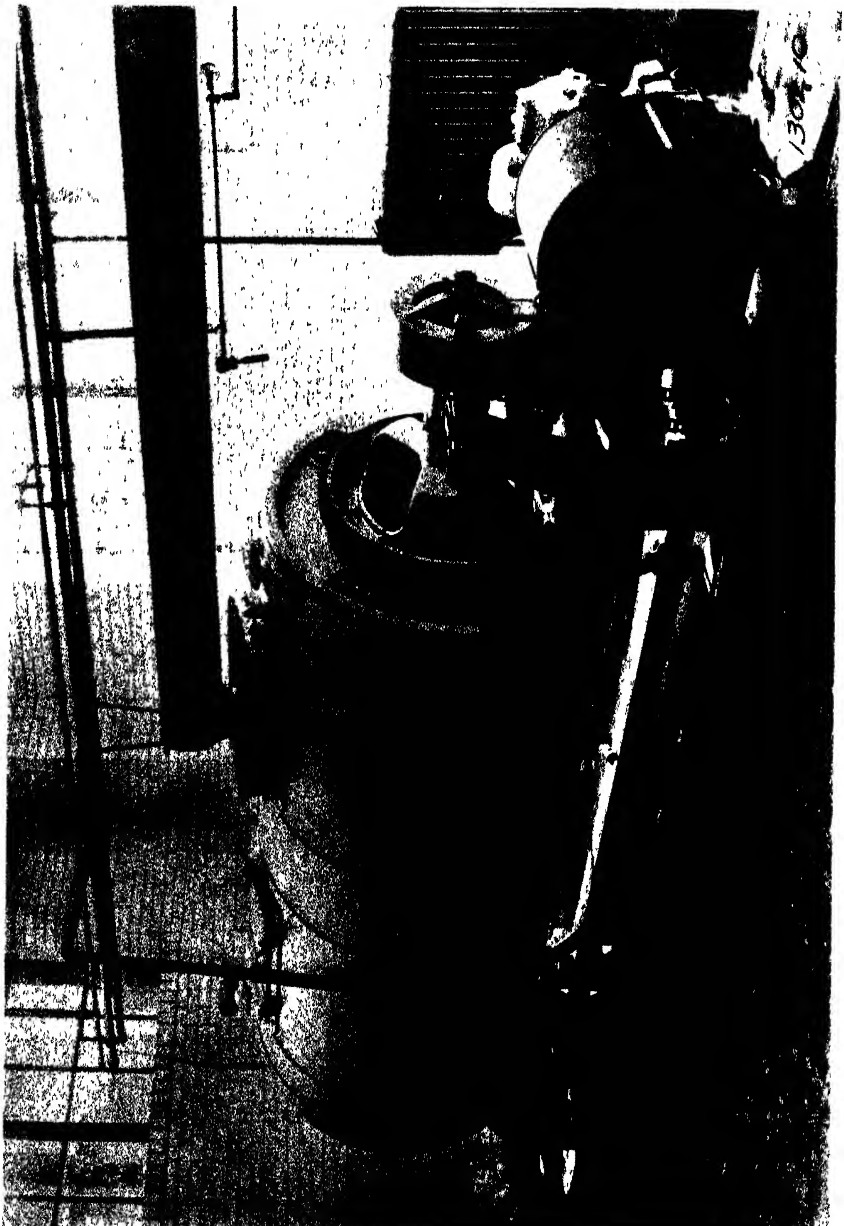

Fig. 4. Rotating Churn Showing Application of Individual Motor Drive

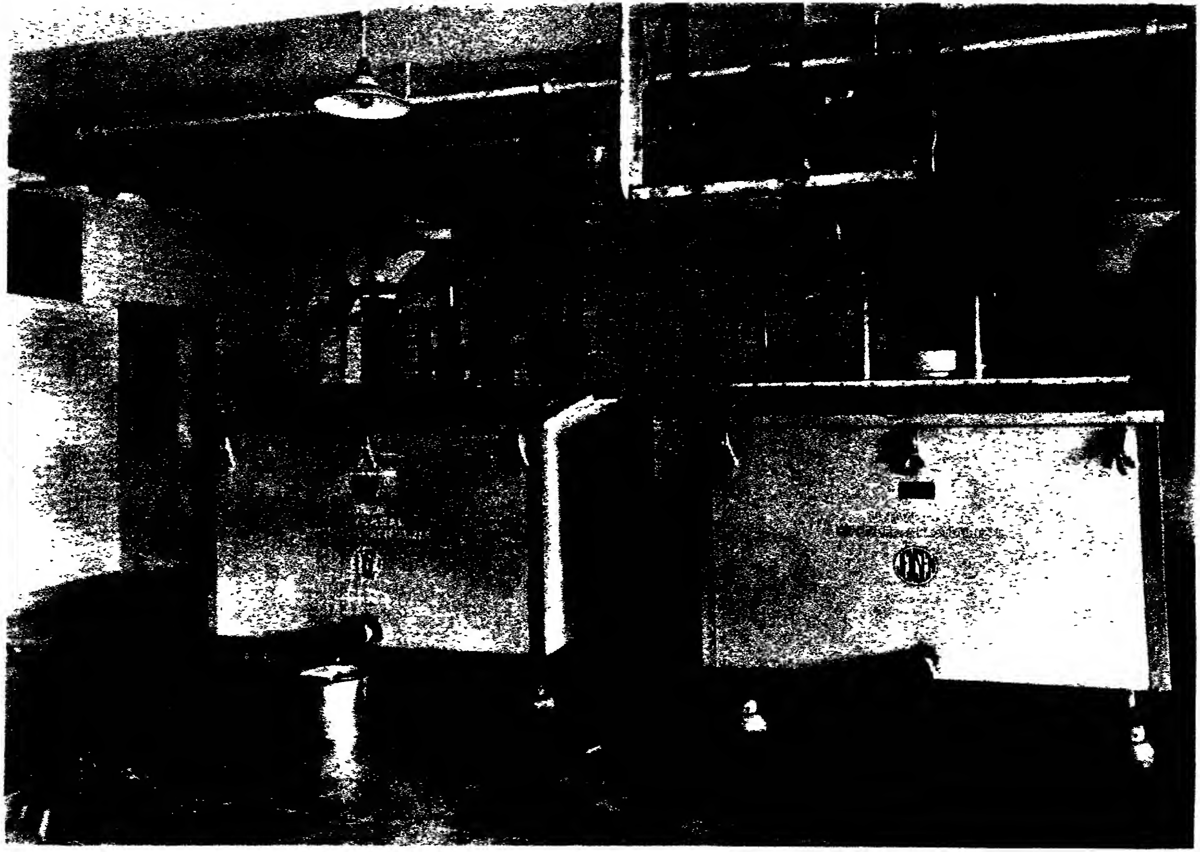

Fig. 5. Pasteurizing Machines both Operated by a 5-Horse Power Motor

THE PROTEINS OF COTTONSEED MEAL[1]

II. NUTRITIVE VALUE

W. B. NEVENS

Department of Animal Husbandry, University of Illinois, Urbana, Illinois

I. REVIEW OF THE PREVIOUS WORK ON THE NUTRITIVE VALUE OF THE PROTEINS OF COTTONSEED MEAL

Cottonseed meal and flour were found by Richardson and Green (1) to be satisfactory sources of protein for the growth of albino rats when these feeds furnished 18 per cent or more protein to the ration. Mendel (2) states that normal growth has been secured for considerable periods when the globulin of cottonseed was fed in suitable concentration, such concentration having been determined by Osborne and Mendel (3) as 18 per cent of the ration. The latter investigators (4) found that "Cottonseed flour forms a suitable adjuvant for the proteins of corn gluten," producing "satisfactory increments of growth" in chickens. In further studies of the value of certain proteins as supplements to corn gluten, these authors (5) demonstrated that the proteins extracted from cottonseed flour by sodium hydroxide solution were efficient supplements to the proteins of corn gluten for the growth of rats. The use of either the cottonseed globulin or the proteins precipitated from alkali extracts of cottonseed flour in an amount equal to 9 per cent of the ration resulted in "satisfactory growth" and when used to the extent of 6 per cent of the ration "considerable growth" was secured. This is interpreted as attesting the excellent quality of cottonseed proteins. McCollum and Simmonds (6) report the maintenance of body weights by rats fed a ration containing 6 per cent of protein derived from cottonseed.

[1] The results presented in this paper formed part of a thesis submitted to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Husbandry.

In studies of the relation of the quality of proteins to milk production, Hart and Humphrey (7) found an equality in efficiency of the proteins of gluten feed, oil meal, distillers' grains and cottonseed meal as supplements to the proteins of corn meal and alfalfa hay. In later experiments (8) of the same nature, cottonseed meal proteins proved less efficient than the proteins of gluten feed, oil meal and distillers' grains. In these experiments, however, the proteins of the feedingstuff tested formed but 40 per cent or less of the protein content of the ration, and the results were calculated upon the basis of the total nitrogen absorbed by the animals.

The digestibility of the proteins of cottonseed meal is stated by Fraps (9) to be 88.4 per cent in the case of steers and sheep; by Henry and Morrison (10) as 84 per cent, for choice and prime cottonseed meal; by Mendel and Fine (11), who employed dogs as experimental animals, as 67 to 75 per cent compared to 88 to 93 per cent for the proteins of meat; by Rather (12), using men as subjects, as 77.6 per cent in contrast to 96.6 per cent for the proteins of meat; and by Pomaski (13), who employed the gastric juice of the dog, as 99 to 100 per cent.

From a review of the literature, it is apparent that investigations upon the nutritive value of the proteins of cottonseed meal are quite limited in extent. In the majority of experiments cited, the investigators drew their conclusions from the maintenance of live weight, increase in live weight, state of health or combinations of these criteria. In most cases the amount of feed consumed is not recorded, so that it is impossible to judge whether or not the results secured were due to a failure of the animals to consume a sufficient amount of feed to cover their energy requirements. In but one series of experiments (7, 8), were the conclusions based upon metabolism studies. Hence, the further study of the nutritive value of the proteins of cottonseed meal constituted the object of the present investigation.

The toxicity of cottonseed meal

Before proceeding with the investigation, it was considered advisable to determine, so far as possible, whether or not the

toxic principle of cottonseed meal is associated with its proteins, and further, whether cottonseed meal would prove injurious to rats as has been found (14) in the case of many other species of animals.

From an examination of the literature, it would seem that there is but little basis for attributing the toxicity of cottonseed meal to its proteins. The assumption that the high protein content of cottonseed meal is responsible for its harmful effects (15) was denied by Dinwiddie (16), who maintains that this theory is not supported by a study of the recorded feeding tests. Withers and Brewster (17) attributed the toxic principle of cottonseed meal to a certain group of the protein molecule which contains loosely bound sulphur, but later work by Withers and associates (18) led them to conclude that the toxicity is due to the presence of "gossypol," a definite chemical compound soluble in ether and aniline. They believe "gossypol" may be changed to a nearly related substance "D-gossypol," the latter being insoluble in ether but soluble in aniline. When in alcoholic solution either of these compounds forms precipitates with the alcohol soluble proteins of wheat flour and of cottonseed meal. They reason that the reduction of the toxicity of cottonseed meal by heating may be due to the inability of the animal to digest the "gossypol" and "D-gossypol" protein compounds. The theory that gossypol is responsible for "cottonseed meal injury" is strengthened by the work of Alsberg and Schwartz (19).

In their series of feeding experiments with albino rats, Richardson and Green (1) and Osborne and Mendel (5) observed no toxic effects, but the cottonseed kernels themselves proved toxic.

In the light of the foregoing discussion, it seems very doubtful if the toxicity of cotton seed meal may be attributed to either its high protein content or to the character of the proteins which it contains. Further, it seems clear that commercial cottonseed meal of good quality may provide practically the entire nitrogenous components of the ration for albino rats over a considerable period of time with no injurious effects becoming manifest.

II. METHODS EMPLOYED IN STUDYING THE NUTRITIVE VALUE OF THE PROTEINS OF COTTONSEED MEAL

Object of feeding experiment. The object of this phase of the experiment was to study the nutritive value of the proteins of cottonseed meal and to compare their nutritive value with that of the proteins of corn and alfalfa hay for the growth of young albino rats. It was planned to feed rations containing a medium amount of protein, derived from the above mentioned sources, and by means of metabolism studies to determine the extent to which the proteins are utilized for maintenance and growth.

General plan of experiment. Young male albino rats in vigorous, healthy condition and having an initial weight of from 100 to 140 grams were employed. The metabolism periods were each seven days in length, two such periods following each other without intermission with each of the experimental rations tested. Before the first metabolism period and whenever the rations were changed, a three day preliminary or transition period, during which the ration to be employed during the metabolism period was fed, was inserted. It was planned to feed the animals as large amounts of the rations as they would consume, the daily feed allotment being slightly greater than the amount consumed.

The rats were placed in individual glass crystallizing dishes 7½ inches in diameter and 3¾ inches in depth, inside measurements. The dishes were provided with weighted wire covers to which were attached large test tubes fitted with rubber stoppers and bent glass tubing, the latter extending downward through the wire cover. The test tubes were kept supplied with ammonia-free water. Large porcelain crucibles for receiving the feed were supported from the covers by means of wire frames. Crystallizing dishes of 60 mm. diameter were employed instead of the crucibles for rations containing alfalfa, which were very bulky. Ventilation was provided by means of a system of rubber tubes which conducted a current of compressed air to the bottom of each dish. From two to three sheets of filter paper, cut to fit the dishes, were placed in the bottom of each dish daily to absorb the urine.

Feces and urine were collected daily. In most cases the filter paper absorbed the urine completely, so that the feces were nearly always found dry. In a very few cases, particularly with rations containing alfalfa which resulted in the production of very bulky feces, there was evidently absorption of urine by the feces, so that it was necessary to extract the feces once or twice with hot acidified water before collecting them. The feces were preserved under 95 per cent alcohol acidified slightly with sulfuric acid. At the end of each seven-day metabolism period, the feces were transferred to large Kjeldahl flasks and digested according to the to the Kjeldahl-Gunning-Arnold method with sulfuric acid, sodium sulfate and mercury. The resulting solutions were transferred to 500 cc. volumetric flasks and aliquots taken for distillation.

After collecting the feces, the urine was extracted from the filter papers by washing with a stream of ammonia-free water acidified with sulfuric acid and held at nearly boiling temperature. The filter paper was thoroughly pulped and pressed out after each extraction by means of a glass rod. From four to six extractions were made, using 40 to 60 cc. of water each time, the sides and bottom of the dish also being thoroughly washed. The extracts were filtered through glass wool into 250 cc. volumetric flasks. The flasks were allowed to remain in the ice box over night. The solutions were then made up to volume at ice box temperature and transferred to 2.5 liter bottles which were kept in a cold storage room at a temperature of 5° to 10° C. until analyzed. About 0.5 gram of powdered thymol was employed as a preservative in each bottle in which the week's urine was collected. The composites were thoroughly mixed and aliquots measured out in the cold for total nitrogen determinations.

The feed was weighed daily into the crucibles and mixed with a little nitrogen-free water to the consistency of a thick paste. The following day the feed residues were scraped out and dried in the same oven and at the same temperature as the rations used. In some cases the animals scattered the feed from the crucibles about the metabolism dish. In such cases the eed

remaining in the metabolism dish at the time of collecting the excreta was carefully separated and added to the feed residues. When thoroughly dry the weight of the feed residues was determined and the amount of feed actually consumed during the seven-day period calculated. By previous tests in this laboratory it was found that the error involved in this calculation due to a difference in the moisture content of the residues and ration was less than 1 per cent, and further that the nitrogen contents of the residues and ration were identical (20).

Preparation of rations. In preparing the experimental rations, the starch used was first dextrinized by heating on the steam bath after the addition of cold water and a few crystals of citric acid. When ground corn formed one of the constituents of a ration, it was mixed with the starch and the starch of the mixture dextrinized. The other ingredients were then added, the agar being dissolved in boiling water and added at the boiling temperature. When necessary more hot water was added and the ingredients thoroughly mixed. The rations were dried on glass plates, placed above the steam bath, finely ground and dried in an oven at a temperature of about 40°C. After drying for several days, the rations were mixed, sampled for analysis and placed in tightly covered glass jars.

The nitrogen free ration consisted of the following:

	per cent
Salts	5
Butterfat	10
Sucrose	8
Starch	74
Agar	3

Water soluble vitamin, 150 mgm. of solids per 100 grams of ration.

The composition of the other rations is shown in table 1. The salt mixture used was compounded according to the formula of Osborne and Mendel (21), while the water soluble vitamin consisted of Osborne and Wakeman's (22) fraction II of the concentrated extract of the water soluble vitamin of brewers' yeast. The stock supply of the latter was prepared in the form of a water solution which was preserved by means of a small quantity of chloroform and kept in the ice box. The butter-

fat was obtained by placing fresh creamery butter in large beakers, heating to a temperature of 50° to 60° on the steam bath, centrifuging for an hour or until the fat became water clear, and then siphoning off the clear fat.

It was planned that all rations containing a protein feedingstuff should carry 10 per cent of protein (N × 6.25), but the actual content of protein was slightly higher, ranging from 10.38 per cent to 11.28 per cent, due to the fact that some of the constituents used in making up the ration had a slightly higher moisture content than the dried rations.

TABLE 1

Composition of experimental rations (expressed in percentage)

CONSTITUENT	RATION						
	1*	2	3	4*	5	6	7
Cottonseed meal	23 9			13 1		10 3	7.7
Corn		72 7		32 3	28.4		19.3
Alfalfa hay			63.5		40.6	35.7	29.3
Starch	55 1	6 3	18.5	33.7	13 0	36.0	25.7
Agar	3 0	3 0		3.0			
Sucrose	5.0	5.0	5 0	5.0	5.0	5.0	5.0
Butterfat	10 0	10 0	10.0	10.0	10.0	10.0	10.0
Salts	3 0	3 0	3.0	3.0	3.0	3.0	3.0
Total	100.0	100 0	100 0	100.0	100 0	100.0	100.0
Total nitrogen content	1.750	1.660	1.806	1.777	1.708	1.790	1.782

* Water soluble vitamin preparation added at the rate of 1.5 mgm. of solids per gram of ration to rations 1 and 4.

In preparing the rations in which two or more feedingstuffs were combined an effort was made to have each feedingstuff furnish an equal amount of digestible protein, using the coefficients of digestibility secured in period 2 as a basis for calculation, but keeping the total content of crude protein the same throughout the experiment, namely, 10 per cent.

The cottonseed meal used in the rations was a part of the same sample which was employed in the analytical study presented in a preceding paper. Through the courtesy of the Plant Breeding Division of the Agronomy Department of this university a

quantity of "high protein" corn containing 2.2 per cent nitrogen was secured, which made it possible to formulate a suitable corn ration containing 10 per cent protein. All of the feeding-stuffs used were in a finely ground condition before compounding the rations.

Accuracy of metabolism work with small animals. Since the accuracy of metabolism work depends in large measure upon the accuracy of the collection of the excreta, especially when such small amounts of nitrogen are involved as in the case of the smaller laboratory animals, several experiments were carried out to test the accuracy of the methods employed.

Each day during period 6, when 6 rats were receiving the same feed mixture, the paper residues remaining after extraction of the urine were collected in glass jars and placed in the ice box. At the end of the metabolism period, the entire mass of residues, including the glass wool used in filtration, was transferred to a 2 liter beaker and boiled for some time with about 1 liter of water acidified with sulphuric acid. The extracts were decanted and the procedure repeated, the acidified water being pressed out from the residues. The extracts were filtered through glass wool, evaporated on the steam bath and transferred to Kjeldahl flasks for total nitrogen determination. The paper residues also, together with the glass wool, were transferred to large Kjeldahl flasks, and total nitrogen determined. The results of these determinations are shown in table 2. The nitrogen extracted in the procedure described just above is assumed to be of urinary origin and is compared to the total amount of urinary nitrogen excreted during the week. It is shown that, as an average of 6 such determinations, the error in the collection of urine amounted to 2.0 per cent of the total nitrogen.

The nitrogen remaining in the paper residues which was not extracted by boiling with acidified water was assumed to be fecal nitrogen. In collecting the feces it was sometimes impossible to entirely remove the fecal matter from the filter papers, especially when the rations tended to cause a laxative condition. Such a condition was not a constant effect with any ration employed, but was more frequent with rations containing alfalfa.

With the latter rations, three filter papers were generally placed in each dish daily, while with the other rations two papers were used. Analysis of the filter paper showed that seven filter papers of the size used contained 1.06 mgm. of nitrogen. In making the calculations shown in table 2 it was assumed that the nitrogen originally contained in the filter papers was insoluble in the hot dilute acid employed in extraction and this has been deducted from the non-extractable nitrogen remaining in the paper residues. To the extent that such nitrogen is soluble in

TABLE 2

Test of the completeness of extraction of nitrogen from filter papers used as absorbents during one metabolism period

RAT NUMBER	EXTRACTABLE N IN PAPER PULP	N IN URINE COLLECTED	TOTAL URINARY N EXCRETED	ERROR IN COLLECTION OF URINE	NON-EXTRACTABLE N IN PAPER PULP	N IN FECES COLLECTED	TOTAL FECAL N EXCRETED	ERROR IN COLLECTION OF FECES	TOTAL N IN PAPER PULP RESIDUES	TOTAL N OF EXCRETA FOR PERIOD	TOTAL ERROR IN COLLECTION
	mgm.	*mgm.*	*mgm.*	*per cent*	*mgm.*	*mgm.*	*mgm.*	*per cent*	*mgm.*	*mgm.*	*per cent*
2	12 5	558.4	570 9	2 2	25 5	546 8	572 3	4 5	1143 2	38.0	3 3
3	15.9	716 3	732.2	2.2	25.8	833 7	859.5	3 0	1591.7	41.7	2 6
5	9 0	619 3	628 3	1 4	22 2	645 3	667.5	3.3	1295 8	29.2	2 3
6	13 2	541 0	554 2	2 4	20 1	615.8	635 9	3 2	1190 1	33.3	2.8
8	11 5	652 5	664 0	1.7	12 9	672 0	684 9	1 9	1348.9	24.4	1.8
9	18.3	764 3	782 6	2 3	28.0	602.0	630.0	4 4	1412 6	46.3	3.3
Average.......	13 4		655.4	2 0	22 4		675 0	3 3	1330.4	35.5	2 7

* After deduction of nitrogen contained in same number of clean filter papers.

hot dilute acid, however, it would tend to offset to a small degree the losses in the collection of urine, although the correction would not be in proportion to the variable total urinary nitrogen. The error in the collection of feces was found to be 3.3 per cent, using the average of six determinations, or, comparing the total nitrogen lost to the total nitrogen excreted in urine and feces during the week, the total error in the collection of both feces and urine is 2.7 per cent.

The results obtained in this test were applied to the metabolism data for period 6, the period during which this test was conducted,

to determine what effect the incomplete collection of the excreta has upon the utilization coefficients. It is evident that an error in the collection of the excreta is reflected directly in the nitrogen balance and in the percentage utilization. Using the average values given in table 2 of 13.4 mgm. of nitrogen representing uncollected urine and 22.4 mgm. of nitrogen representing uncollected urine and 22.4 mgm. of nitrogen representing uncollected feces during a seven day period, and applying them to the data for the individual animals during period 6 it is found that the percentages of utilization of absorbed nitrogen as given in the tables are approximately 2 per cent too high, while the percentages of absorbed nitrogen retained are slightly more than 3 per cent too high. Like results are obtained for period 7 during which the animals received the same ration as in period 6.

The completeness of the collection of urine was tested in still another way, that of the recovery of urea which was added in the form of a standard solution to the daily feed. Two mature rats were employed in the test. After the excretion of urinary nitrogen had been reduced to a nearly constant level by subsistence on protein free rations for seven days, known amounts of urea were added to the ration.

The excretion of this extra nitrogen was very prompt, as indicated by the results of the test as shown in table 3. In the case of rat 10, the results are somewhat difficult to interpret, owing to the fact that the consumption of feed decreased rapidly, evidently resulting in catabolism of small amounts of body protein to furnish energy for the body. By using the figures for the average excretion of nitrogen during the three days preliminary to the first urea day as the level of the endogenous nitrogen during the three urea days, the apparent recovery of the urea nitrogen amounted to 119 per cent. Similar results are obtained if the average nitrogen excretion during the preliminary and subsequent periods are employed. If it be assumed that, owing to a decrease in feed consumption below that of the energy requirements, the endogenous nitrogen should be taken as corresponding to that in the subsequent period, then the recovery of the urea nitrogen was approximately 100 per cent. Undue

emphasis should not be placed upon the results given by this animal, however.

With rat 11 more reliable data were obtained as it was not evident that the feed consumption was deficient in meeting the energy requirements. By using the average nitrogen excretion during both preliminary and subsequent periods as the level of the amount of body nitrogen excreted, the recovery of

TABLE 3

Test of the completeness of collection of urine by addition of urea to the ration

DAY	LIVE WEIGHT	FEED EATEN	UREA N ADDED	DAILY URINARY N
		Rat 10		
	grams	*grams*	*mgm.*	*mgm.*
1	182	10.5	0	35.6
2		10.5	0	24.0
3		10 5	0	23.5
4	178	6.1	42.1	74.6
5		6 1	42.1	83.0
6		6.1	42.1	76.0
7		4.6	0	35.9
8	167	5.6	0	35.8
		Rat 11		
1	176	7.2	0	42 8
2		7.2	0	30.2
3		7.2	0	39.8
4		7.7	56.5	82.8
5		7.7	56.5	101.8
6		5.4	0	37.5
7	164	5.4	0	29.3

urea nitrogen amounted to 95 per cent of that fed. If the average of the amounts of nitrogen excreted during days 3 and 6 be used as this level, then the recovery of urea nitrogen was practically 100 per cent.

It is evident from the data presented concerning the recovery of urea nitrogen that the method for the collection of urine as employed in these experiments, gives very nearly quantitative results.

Further tests of the metabolism method employed, which were performed in this laboratory and are described below, show that loss of ammonia due to bacterial decomposition of the urine does not occur to any appreciable extent.

In the first test, three portions of urine of 5 cc. each were measured out for total nitrogen determination. At the same time 5 cc. portions of urine were added to each of six metabolism dishes containing the usual number of filter papers. Three of these dishes were allowed to stand at room temperature in the metabolism laboratory, while the remaining three were placed in an oven at a temperature of about 40°C. At the end of twenty-four hours, the urine was collected from all six dishes in the same manner as employed in the metabolism work, i.e., by washing with hot acidified water. As a result of this test it was found that 5 cc. of urine contained 28.18 mgm. of nitrogen, while the amounts of nitrogen recovered from the dishes kept for twenty-four hours at room temperature and at 40°C. were, respectively, 27.61 mgm. and 27.54 mgm.

In the second of these tests, the urine from one rat receiving a constant amount of the same ration was collected daily. On the first, third, and fifth days the urine was collected at once by washing with acidified water in the usual manner. The urine was made up to a volume of 250 cc. and aliquots taken at once for total nitrogen determinations.

On the alternate days the urine was not collected at the end of the twenty-four hour period, but the filter paper was moistened and the dish allowed to stand another twenty-four hours in the metabolism laboratory before extraction in the usual maner. The rat meanwhile was transferred to a clean dish. At the end of the second day the urine was collected by washing as usual, made up to volume, and aliquots taken for total nitrogen determination. The results of the test are shown in table 4. It is evident that there was no appreciable loss of nitrogen due to bacterial decomposition even after the metabolism dishes had stood for two days.

How shall the nutritive value of proteins be compared? In attempting to compare the biological values of various feeding-

stuffs, it is first necessary to select a suitable basis for comparison. Several different methods for comparison are in use. As pointed out in the introduction one of the most common methods is to base conclusions upon the character of the growth secured, the principal index in such a case being the gain in live weight. Some of the data from table 1 of the appendix are brought together in table 5. These data were all obtained in periods 2 and 3. The rats consuming the cottonseed meal ration showed marked fluctuations in gain in live weight which can not be accounted for on the basis of a variable food intake. With the corn ration, there was a gain in weight by one rat in one period

TABLE 4

Effect of allowing metabolism dishes to stand twenty-four hours and forty-eight hours before the collection of urine

DAY OF EXPERIMENT	DAILY URINARY N WHEN COLLECTED AT END OF TWENTY-FOUR HOURS	DAILY URINARY N WHEN COLLECTED AT END OF FORTY-EIGHT HOURS
	mgm.	*mgm.*
1	57.9	
2		64.9
3	60.8	
4		67.3
5	63.2	
6		60 3
Average.............	60 3	62.1

only. The nitrogen of the ration, however, was being used by the body to a considerable extent, for on a nitrogen-free ration the same animals lost 16 to 19 grams in weight during a period of equal length, compared to 1 to 2 grams on the corn ration. Likewise, there was also a large variation in gains in weight by the rats receiving the alfalfa ration, the average gains of rats 7 and 8 being almost zero. It is probable that many factors other than the quality and amount of the protein consumed influence the gain in weight, such as the proportion of carbohydrates in the ration, amount of water drank, exercise, the proportions of gain which is protein or fat, etc. While interpretations based upon the gain in live weight may lead to reliable

conclusions in some instances, the adoption of such a criterion in the present case would certainly be a fallacious procedure.

It is a matter of common knowledge that all animals require protein food for keeping the body tissues intact, known as the maintenance requirement, and secondly, that growing animals need an additional quantity of protein for the construction of new tissue. If a standard for the comparison of the value of the proteins of feedingstuffs for growth is based simply upon the proportion of the nitrogen of the feedingstuff which is retained by the body, the values secured in such a manner are subject to gross errors. With such a method of computation the apparent value of the proteins for growth depends largely upon the nitrogen intake, or, in other words, upon the amount of feed eaten, and this in turn is subject to individual idiosyncracy and the palatability of the ration. As mentioned elsewhere, when the ration proves unsatisfactory, rats tend to eat less and less from day to day. By reference to table 5 it may be seen that both rats 5 and 6 ate less of the corn ration during period 3 than during period 2. Rat 5, during period 2, retained 16 per cent of the nitrogen absorbed, but during period 3, when the amount of feed consumed was evidently too little to maintain the animal's live weight, the nitrogen of the excreta was greater than the nitrogen intake, so that there was a loss of nitrogen from the body resulting in a negative value for the percentage of absorbed nitrogen retained. Similarly, the percentage of absorbed nitrogen retained by rat 6 falls from 23 per cent in period 2 to 9 per cent in period 3, a change which in this instance may also be attributed to a decreased food intake. Were the average percentage of the absorbed nitrogen retained by rats 5 and 6 taken as a measure of the utilization of the proteins of corn for growth, it would be a distorted picture of the facts.

There seem to be factors other than the amount of feed consumed which render the use of the percentage of absorbed nitrogen retained an unsatisfactory criterion of the utilization value of the proteins of feedingstuffs. As may be seen by reference to table 5, the percentage of nitrogen retained by rat 7 in periods 2 and 3 falls from 23 per cent to 8 per cent, and in the case of

rat 8 the percentage falls from 16 per cent in period 2 to 6 per cent in period 3. These violent fluctuations are not due entirely to a decreased nitrogen intake, for in the case of rat 7 the feed intake increased slightly during the second period. They are, however, associated with a slightly decreased digestibility, although there may be other causative factors.

TABLE 5

A comparison of three methods of expressing the utilization of proteins

RAT NUMBER	PERIOD	RATION	FEED CONSUMED DAILY	GAIN IN WEIGHT FOR PERIOD	UTILIZATION OF ABSORBED N FOR MAINTENANCE AND GROWTH*	ABSORBED N RETAINED*
			gm.	*gm.*	*per cent*	*per cent*
1	2	Cottonseed meal	9.52	11	63	31
1	3	Cottonseed meal	9.48	6	65	29
2	2	Cottonseed meal	8 66	9	64	21
2	3	Cottonseed meal	8 57	5	64	17
3	2	Cottonseed meal	11.51	12	71	44
3	3	Cottonseed meal	12.47	11	70	43
4	2	Corn	7 44	2	49	15
4	3	Corn	8.05	0	47	15
5	2	Corn	7 66	0	54	16
5	3	Corn	6.30	−1	43	
6	2	Corn	7 49	−1	55	23
6	3	Corn	6 35	−2	48	9
7	2	Alfalfa hay	9.33	6	62	23
7	3	Alfalfa hay	9 50	−5	57	8
8	2	Alfalfa hay	9.19	2	58	16
8	3	Alfalfa hay	8.20	−2	57	6
9	2	Alfalfa hay	11.42	3	67	22
9	3	Alfalfa hay	13.67	7	73	38

* For method of calculation of these percentages, see table 1 of the appendix.

Any suitable criterion used in feeding experiments for the comparison of the utilization of proteins for growing animals must necessarily consider the effect of the proteins in providing nitrogen for maintenance, for in growing animals these processes proceed concurrently. It is doubtful if the true protein requirement for the maintenance of a growing animal can be determined by feeding a ration containing protein, for Waters (23) has shown

that when young steers received a ration which just maintained their live weight some of the growth processes continued. Similar results were obtained by Aron (24).

Perhaps the nearest approach to the determination of the exact amount of nitrogen required for the maintenance of a growing animal is a study of the nitrogen excretion when the ration consists entirely of carbohydrates and this is being taken in an amount in excess of the body's energy requirement. Under such conditions the nitrogen excretion falls to a very low level, often to one third or less of that during starvation, as shown by Folin (25), Landergren (26), Cathcart (27) and Thomas (28). The amount of protein then being catabolized has been defined by Rubner (29) as the "wear and tear" quota of protein metabolism, which requires a "repair quota" of protein in the diet in order to replace it. A "growth quota" must be supplied the young animal in addition to the "repair quota" in order that growth may take place. Using dogs as experimental animals, Michaud (30) found, when protein in the form of casein or dog tissue was fed in amounts equivalent to the protein minimum after the metabolism had been reduced to this level, that there was no further loss of nitrogen from the body. Thomas (28) found, after the reduction of the nitrogen excretion by a carbohydrate diet to the minimum level, that nitrogen equilibrium could be restored by the ingestion of an amount of protein nitrogen in the diet equal to the amount of nitrogen being eliminated in the excreta.

On a nitrogen-free diet the amount of nitrogen excreted daily in the feces was about 1 gram, and this amount was not increased with a nitrogen intake of 3 grams furnished by a highly digestible protein. With diets producing a large bulk of feces he found that a greater proportion of digestive juices was eliminated, increasing the nitrogen content of the feces.

In the interpretation of the feeding experiments which follow it is assumed that the amount of protein required for body maintenance is a constant value for each individual at a given weight. Such an assumption is entirely in harmony with the theories of many investigators in the fields of both human and animal nu-

trition. Folin (25), as a result of his study of the different forms in which nitrogen is excreted on high and low protein diets, was led to formulate his theory of two distinct types of metabolism. The endogenous is most characteristically represented by the excretion of creatinine, which, "on a meat-free diet is a constant quantity, different for different individuals, but wholly independent of quantitative changes in the total amount of nitrogen eliminated." Folin's results have been substantiated by an immense amount of investigation concerning urinary creatinine, and his theory of protein metabolism is now almost universally accepted in its main essentials, although it has been necessary to modify this view slightly with our increased knowledge of the chemistry of the proteins.

The constancy of the protein minimum for the individual is accepted by Lusk, Thomas and others. That this minimum differs between individuals and is subject to slight variation due to environmental, temperamental and dietary changes, possibilities which are not precluded by Folin's theory, is brought out by Cathcart (31):

> As regards the uniformity of the protein minimum it may be definitely stated that there is no single minimum—common to all men and to all conditions. Rubner, Caspari and others also hold firmly to this opinion. Caspari quotes the work of Larguier des Bancels in 1903 in confirmation of this belief in the existence of mutiple protein minima. The facts that can be cited against a common minimum are many in number. Thus the caloric value of the diet given influences very materially the amount of nitrogenous material required, as is shown, for example, in the experiments of Voit and Korkunoff. Then, as Rubner has pointed out, the temperature influences quite markedly the course of protein metabolism. Finally, another factor of considerable importance may be mentioned, the activity of the organism.

In the sphere of animal nutrition, the constancy of the maintenance requirement for farm animals is recognized by Kellner, Armsby and Haecker. C. Voit and Kellner also proved conclusively that work production of varying intensity by farm animals does not increase the protein metabolism appreciably.

In this connection it should be stated that some of the current theories of protein metabolism are not in complete harmony with that just mentioned. Among these are the reversible reaction theory of Sherman (32), which seeks to account for the functions which the food protein serves in body maintenance by the assumption that the absorption of the amino acids liberated in digestion causes an increased concentration of these in the tissues which checks or even reverses the hydrolysis of tissue protein. This theory is hardly compatible with the known facts regarding the constancy of the endogenous metabolism, which has been found (33) to be uniform from hour to hour, as evidenced by the creatinine elimination, even during digestion and absorption of proteins. Absorption of the protein digestion products from the alimentary tract presumably occupies only a portion of the twenty-four hour period, so that even if the endogenous catabolism were inhibited by the increased concentration of amino acids, it would be only temporary, for it has been shown (34) that, in adult rats, protein feeding has only a very slight effect upon the amino acid concentration in the tissues. This known slight increase in the amino acid content of the tissues during digestion would not be of sufficient magnitude to inhibit the action of digestive enzymes when a digestion experiment is conducted in vitro. Further, it is unreasonable to assume that anabolism and catabolism of tissue proteins are simply reversible phases of the same reaction and that both these processes are promoted by the same enzyme. In the young growing animal protein feeding has been demonstrated (34) to increase considerably the amino acid content in the tissues. Were the endogenous metabolism inhibited entirely during the time this concentration is maintained, as must be assumed from the reversible reaction theory, then the catabolism of tissue protein per unit of weight in the young growing animal would be but a fraction of that of a mature animal.

Osborne and Mendel (35) explain the maintenance protein requirement upon the need of certain amino acids to serve special physiological functions, such as the formation of the active principles of the internal secretions and hormones. This theory

assumes, therefore, that when the animal is receiving a nitrogen-free ration, body tissue must be catabolized to furnish the essential amino acids, but that, on the other hand, when a ration containing a complete assortment of amino acids in sufficient amount is being consumed the endogenous metabolism is only a fraction of that on a non-nitrogenous ration, and that then only the catabolism of the internal secretions or the tissues which regulate metabolism would be affected. Under these conditions the muscles would scarcely be affected and the creatinine elimination would bear little relation to the endogenous metabolism. Moreover, the theory does not satisfactorily account for the effect of ammonium salts, mixtures of amino acids and single amino acids in partially supplying nitrogen for maintenance.

Since the plan of procedure and method of calculation employed in this investigation are dependent primarily upon the basic assumption that the endogenous metabolism of the animal organism is constant in character and amount for an individual at a given age and weight, an examination of the data obtained during all the metabolism periods was made in order to ascertain, if possible, whether this assumption is substantiated by the experimental results at hand. In making this examination, the data embodied in appendix table 1 were employed to obtain the first set of values shown in the column headed "As determined" under each "period" of table 6. These values were obtained by deducting the sum of the endogenous nitrogen and the metabolic nitrogen in the feces from the daily urinary nitrogen and calculating the percentage of the daily nitrogen intake which the remainder forms. The second column of values under each "period," headed "As calculated," was obtained in the same way as those in the first column, except that the average value for daily urinary nitrogen as determined with nine rats in period 1, i.e., 22 mgm. per 100 grams live weight, is used in calculating the "endogenous nitrogen" for periods 2 to 7, inclusive, instead of the individual values determined in the same period.

It is shown in table 6 that the individual daily urinary nitrogen values for rats 2, 5, and 9 are above the average, while those for

rats 3, 6 and 8 are below the average. Hence, for comparison, rats 2 and 3, 5 and 6, and 8 and 9 are arranged in pairs. The rats of each pair received the same rations throughout the experiment. It is natural to assume that two animals of the same age and weight and in a comparable nutritive condition will utilize the same ration with an equal degree of efficiency, subject of course to inherent individual variability. By reference to table 6, it may be noted that this holds true to a very great extent, although the natural variations to be expected in biological work of this kind are in evidence.

TABLE 6

The proportion of the daily intake of nitrogen above maintenance which appears in the urine (expressed in percentage)

RAT NUMBER	PERIOD 2		PERIOD 3		PERIOD 4		PERIOD 5		PERIOD 6		PERIOD 7	
	As determined	As calculated	As determined	As calculated	As determined	As calculated	As determined	As calculated	As determined	As calculated	As determined	As calculated
2	12.0	16.3	9.8	13.1	1.7	5.3	8.3	12.4	8.9	13.4	8.8	13.7
3	8.8	8.3	9.4	8.9	7.8	7.2	7.3	6.9	9.9	9.3	9.9	9.2
5	26.5	29.1	35.0	38.2	18.7	21.0	18.5	21.1	12.3	14.4	11.4	13.7
6	23.9	20.0	31.3	26.7	21.0	17.5	16.4	12.3	12.6	9.5	14.0	11.1
8	9.1	7.4	7.8	5.8	15.6	14.3	10.4	8.9	14.3	12.5	9.7	7.7
9	4.1	5.5	1.9	3.1	15.8	17.3	14.9	16.4	16.0	17.6	16.4	18.1

Considering first the values listed under the headings "As determined" in each period it is evident that there is a marked uniformity exhibited by the animals of each pair throughout the different experimental periods with but few exceptions. For example, it is shown that rats 2 and 3 eliminate in the urine about the same proportion of the nitrogen intake above maintenance "as determined," with the exception of periods 2 and 4. Rats 5 and 6 show quite uniform results throughout the entire six periods. Rats 8 and 9 do not very widely from each other in periods 4, 5 and 6. Moreover, certain rations seem to have a pronounced effect on these percentages. Rats 5 and 6 received the corn ration during periods 2 and 3, and the corn-

cottonseed meal ration during periods 4 and 5. With both of these rations, the proportion of the daily nitrogen intake eliminated in the urine was greater than with the other rations, but both animals behaved alike in this respect.

On the other hand, when the average values for the endogenous nitrogen of the urine are used in calculating maintenance, the variations in the percentages of the nitrogen intake above maintenance appearing in the urine of the animals of each pair are greatly exaggerated in 14 of the 18 cases involved, as shown under the headings "As calculated." In one of the four cases, that of rats 5 and 6, period 7, there is no change. In the other three cases, those of rats 2 and 3, period 4, and rats 8 and 9, periods 2 and 3, the spread is lessened slightly. In many cases the use of an average maintenance factor increases the spread between the animals of a pair as much as 200 per cent. These data seem to indicate quite conclusively that the endogenous metabolism is a function of the individual animal and that this is a definite and probably constant value under a given set of conditions. This is quite in harmony with the theory of Folin (25) respecting the constancy of endogenous metabolism. In calculating the results of these experiments, therefore, the use of individual maintenance values is evidently justifiable.

If, having determined the minimal "wear and tear" quota of an animal by appropriate metabolism experiments, feeding tests are then initiated to study the utilization of the proteins of feedingstuffs by that animal, it is possible to calculate the proportion of the nitrogen excreted in the urine which is of endogenous origin and likewise the amount of fecal nitrogen whose source is metabolic. This method follows closely that of Thomas (28) in calculating the biological values of foodstuffs. Such a criterion evaluates the proportion of the nitrogen of the food which is actually utilized by the animal in its metabolism, whether the animal is consuming an amount of protein which is not quite sufficient for it to maintain its live weight, or whether growth is permitted. The values obtained by applying this method of calculation to the data of metabolism periods 2 and 3 are shown in the last column of table 5. An inspection of these values

shows that this method overcomes some of the objections raised to the other methods. When the gain in live weight falls to zero or a little below, but at the same time it is evident that some of the nitrogen of the ration is being used by the animal, the percentage "utilization of the absorbed nitrogen for maintenance and growth" is lowered, but is, nevertheless, a very distinct positive value. With a slight decrease in food intake, there is usually a corresponding fall in the "utilization of absorbed nitrogen for maintenance and growth" coefficient, but this decrease is not so extreme as when the results are calculated upon the basis of the "absorbed nitrogen retained." Moreover, a decrease in the feed intake to just below the maintenance level does not result in a negative value. On the whole the "utilization of absorbed nitrogen for maintenance and growth" coefficients are much less variable than those of the "absorbed nitrogen retained." The former method is subject to a coefficient of variability of 8.4 per cent when all of the values obtained in the six metabolism periods are considered, and a mean is assumed for each ration. Similarly, the same values when calculated upon the basis of the percentage of "absorbed nitrogen retained" have a coefficient of variability of 27.7 per cent, a striking and important difference.

In this investigation, therefore, the endogenous metabolism of the experimental animals was studied during a metabolism period in which a nitrogen-free ration was fed, and this was followed by six metabolism periods in which the proteins of cottonseed meal were compared with those of corn and alfalfa hay.

III. DISCUSSION OF THE RESULTS

Metabolism of the rat on a nitrogen-free ration. During the first eleven days of the experiment the rats which had been consuming an ordinary stock ration were given nitrogen-free rations prepared as described above. On the fifth day collection of the feces and urine was begun, and continued for seven days. In order to check the results secured during the first period of the experiment, three of the rats were again placed on nitrogen-free

rations during period 6, after having received nitrogenous rations during the intervening time. The principal data of these trials are included in table 7. The rats lost slightly more than 2 grams of weight per head daily. For the first few days of the period the animals ate the ration in large quantities, but as they apparently found the feed unsatisfactory, they consumed smaller and smaller

TABLE 7

Metabolism of the rat when receiving a nitrogen free ration

RAT NUMBER	PERIOD	INITIAL WEIGHT	FINAL WEIGHT	AVERAGE FEED CONSUMED DAILY	DAILY URINARY NITROGEN	DAILY FECAL NITROGEN	DAILY URINARY N PER 100 GRAMS LIVE WEIGHT	FECAL NITROGEN PER 100 GRAMS FEED
		grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*
1	1	99	88	6.51	25	17	27	253
2	1	118	102	7 43	31	19	28	255
3	1	134	116	9.07	26	24	21	259
4	1	135	118	8.79	24	22	19	251
5	1	120	104	7.29	28	20	25	273
6	1	129	110	7.86	21	21	18	270
7	1	123	107	7.43	23	20	20	266
8	1	122	109	8.14	22	24	19	298
9	1	126	114	7.43	29	18	25	246
Average				7.78			22	264
1	6	113	102	6.10	22	19	20	306
4	6	135	130	9.02	16	20	15	223
7	6	118	105	4.76	24	17	21	357
Average				6.63			19	295

amounts from day to day, and a few of the animals scattered the feed from the containers at once upon being fed.

It was found that, while subject to some individual variation, the amount of urinary nitrogen per 100 grams of live weight is fairly constant, the average value of 22.4 mgm. obtained agreeing almost exactly with that found by Mitchell (20) in a large number of metabolism periods. From the results secured in period 6 it appears that there is a slightly less intense endogenous metabolism as the animal becomes older, as evidenced by a decreased

excretion of urinary nitrogen per 100 grams live weight. The slight increase in the case of rat 7 during period 6 as compared with period 1 is evidently due to a deficient food consumption during the former period, necessitating the catabolism of body protein to furnish energy. The individual values obtained in period 1 for urinary nitrogen per 100 grams live weight are used in the subsequent tables for calculating the utilization of the various rations, the values always being corrected to the average live weight of the particular animal during that period.

The quantity of fecal nitrogen per 100 grams feed when the rat is consuming a nitrogen-free ration is quite a constant factor, although this relationship seems to be affected somewhat by extremes in the amount of feed consumed, as may be noted in the case of rats 4 and 7, period 6. Perhaps a more potent factor in causing this fluctuation is the varying amount of filter paper eaten, as found by Mitchell (20) in an experiment in this laboratory in which rats during one period had no access to filter paper and during the other actually consumed some paper.

It is recognized that the calculation of the metabolic nitrogen in the feces by the method described is subject to an error when applied to a variety of rations. Were the content of crude fiber in all rations the same as in the synthetic nitrogen-free ration, the assumption that the metabolic nitrogen of the feces varies directly with the amount of feed consumed would be valid, but with rations varying as widely in the percentage of crude fiber as the corn and alfalfa rations, the adoption of such an assumption evidently leads to an error of undetermined magnitude. However, the method of correcting the absorbed nitrogen and the nitrogen balance, by the use of the factor for metabolic fecal nitrogen obtained on nitrogen-free rations, undoubtedly gives values nearer the truth than if no such corrections were made, since the actual metabolic fecal nitrogen on the experimental rations containing protein was very probably greater per 100 grams of food consumed than the factors used. In computing the amount of metabolic fecal nitrogen shown in the tables that follow, the values for fecal nitrogen per 100 grams feed eaten in

period 1 in the case of each animal are applied to the data for the same animals in later periods.[2]

If it is true, as seems probable from the meager data obtained, that the endogenous metabolism of the rat becomes less intense per unit of live weight as the animal approaches maturity, then in conducting investigations of the kind under consideration it would, no doubt, be advisable to introduce a metabolism period using a nitrogen free ration every six or eight weeks. With these data available it would be possible to make linear corrections for any changes in the requirement of the basal metabolism. In the tables showing the utilization of the proteins which follow, such corrections have not been attempted with the limited number of data at hand, but should the data secured with rats 1 and 4 be used for such a purpose, it would necessitate changes in the utilization coefficients given of not more than 1 to 2 per cent as a maximum.

Palatability of rations. The results obtained in the six metabolism periods during which nitrogenous rations were fed are summarized in table 8.

From an inspection of the figures giving the amounts of feed consumed daily it is evident that all rations containing cottonseed meal were readily consumed by the animals, attesting to the palatability of this feed, even when forming as much as 24 per cent of the ration. When corn was the sole source of protein in the ration the amounts of feed consumed were smaller than with any other ration. Ground corn seems to be less palatable to rats than whole corn for the latter is usually eaten readily. Perhaps another reason why less of the corn ration was consumed than the alfalfa ration, for example, is that the corn ration was much more digestible and had a higher calorific value, so that less of it was required to supply the energy requirements. The ration in which cottonseed meal and corn were combined was consumed in greater quantities than the corn ration but not so freely as the cottonseed meal ration. Alfalfa hay proved very palatable, as all rations of which it formed a part were readily eaten.

[2] These values, as well as those for urinary nitrogen, when being used for these calculations, were extended to one more decimal place than shown in table 7.

TABLE 8

The utilization of the proteins of cottonseed meal, corn and alfalfa hay; summary of results

RAT NUMBER	PERIODS	RATION	AVERAGE LIVE WEIGHT	FEED CONSUMED DAILY	ABSORBED NITROGEN	ABSORBED NITROGEN RETAINED	ENDOGENOUS NITROGEN	UTILIZATION OF ABSORBED NITROGEN	ABSORBED N RETAINED
			grams	*grams*	*mgm*	*mgm*	*mgm*	*per cent*	*per cent*
1	2 + 3	Cottonseed meal	98	9.50	124.8	54.5	25.3	64	30
2	2 + 3		109	8.62	107.1	38.2	30.4	64	19
3	2 + 3		127	11.99	169.6	91.3	28.0	71	44
Average			111	10.04	133.8	61.3	27.9	66	31
1	4 + 5	Cottonseed meal + alfalfa hay	114	10.83	125.9	52.9	30.6	67	26
2	4 + 5		126	11.06	131.7	58.1	35.7	71	29
3	4 + 5		159	15.68	185.0	89.5	33.7	67	34
Average			133	12.52	147.5	66.8	33.3	68	29
2	6 + 7	Cottonseed meal + alfalfa hay + corn	136	9.82	124.3	45.6	38.2	63	21
3	6 + 7		186	14.01	173.0	72.5	39.4	65	27
Average			161	11.92	148.7	59.0	38.8	64	24
4	2 + 3	Corn	118	7.75	118.9	34.6	22.8	48	15
5	2 + 3		108	6.98	105.9	24.7	27.1	49	8
5	2 + 3		115	6.92	104.5	34.1	20.3	52	16
Average			114	7.22	109.8	31.1	23.4	49	13
4	4 + 5	Cottonseed meal + corn	129	9.81	141.4	59.5	24.9	60	30
5	4 + 5		118	8.30	127.8	43.6	29.2	59	21
6	4 + 5		124	8.11	120.2	48.9	22.3	60	28
Average			124	8.74	129.8	50.7	25.5	60	26
5	6 + 7	Cottonseed meal + alfalfa hay + corn	139	10.90	136.9	49.3	34.9	62	18
6	6 + 7		141	11.20	146.8	64.8	25.1	61	28
Average			140	11.05	141.9	57.1	30.0	61	23
7	2 + 3	Alfalfa hay	104	9.42	99.4	37.2	21.4	60	16
8	2 + 3		103	8.69	92.9	33.7	20.0	58	11
9	2 + 3		121	12.55	128.1	61.2	29.4	70	30
Average			109	10.22	106.8	44.0	23.6	62	19
7	4 + 5	Alfalfa hay + corn	115	12.64	149.1	56.8	23.3	54	20
8	4 + 5		118	14.08	175.8	78.9	23.3	59	28
9	4 + 5		134	12.51	166.6	70.6	32.7	62	29
Average			122	13.08	163.8	68.8	26.4	58	26
8	6 + 7	Alfalfa hay + corn + cottonseed meal	142	11.81	152.6	65.0	27.0	61	26
9	6 + 7		154	13.06	184.0	76.1	38.0	62	29
Average			118	12.83	168.3	70.6	33.0	61	27

Utilization of proteins. In the summary of results shown in table 8 two methods of calculating the utilization of the proteins fed are included for comparison, although, for reasons discussed above, the second method, namely, the utilization of the absorbed nitrogen for both maintenance and growth, is employed in the discussion here.

The utilization of the nitrogen absorbed from a cottonseed meal ration containing 10 per cent of crude protein was found to be 66 per cent, using the average results of six metabolism periods with three rats. The utilization of the proteins of alfalfa hay was found to be only slightly less than that of cottonseed meal, namely, 62 per cent.

When these two feeds were combined in such proportion that each furnished about an equal amount of digestible protein to the ration, very interesting results were secured, indicating a slight supplementary effect of the proteins from these two sources. This effect was not pronounced, the utilization percentage being 2 per cent above that of cottonseed meal alone and 6 per cent above that of alfalfa hay alone. It is noted that during the periods when the cottonseed meal alfalfa hay ration was fed, greater quantities of feed were consumed and larger amounts of nitrogen were absorbed than with either the cottonseed or alfalfa hay rations alone, which may in some unknown way have operated in effecting a more efficient utilization of the nitrogen, although the same conditions hold true in the case of both groups of rats which received either the corn or the alfalfa ration during two periods and were then changed to rations containing proteins from both sources.

It was found that the proteins of corn were utilized the least efficiently of those of the three feedingstuffs compared. When corn was combined with cottonseed meal or with alfalfa hay the resulting utilization coefficients tended toward a mean of the utilization coefficients secured with these feedingstuffs when fed alone, but were nearer that of the feed other than corn. For example, the utilization coefficients found for the corn and cottonseed meal rations were 49 per cent and 66 per cent respectively, the mean of these two being 57.5 per cent, but

the utilization coefficient found for the cottonseed meal-corn ration was 60 per cent. Possibly this represents a slight supplementary relationship.

The results obtained with the ration in which cottonseed meal, corn and alfalfa hay were combined were remarkably uniform. Of the twelve values obtained with rats receiving this ration during two metabolism periods each, the lowest value was 57 per cent and the highest 67 per cent, the average of all being 63 per cent. The combination of the proteins from three different sources failed to indicate any farther supplementary effect of the proteins.

The high nutritive value of the proteins of cottonseed meal manifested by these experiments is in substantial accord with the conclusions of Richardson and Green (1), Osborne and Mendel (3, 4, 5, 6) and McCollum and Simmonds (6). They do not seem to be in harmony with the findings of Hart and Humphrey (8) who studied the utilization of the proteins of cottonseed meal for milk production, but since growth and milk production are dissimilar functions an absolute comparison of the results of the two experiments is not valid.

Correlation of chemical composition with nutritive value. In seeking for an explanation of the differences in the nutritive value of the proteins of these feedingstuffs based upon differences in their chemical makeup, it is evident first of all that their nutritive values do not vary so widely as the analytical data at hand would indicate. For example, the differences found between the utilization of the proteins of cottonseed meal and alfalfa hay was but 4 per cent, while from an examination of the data in table 5 of a preceding paper, it is apparent that cottonseed meal contains more than twice as much arginine nitrogen and nearly twice as much histidine nitrogen as alfalfa hay, while the latter contains more than three times as much nonprotein nitrogen as the former.

Several theories may be advanced in explanation of this apparent inconsistency. In the first place, alfalfa hay is shown to have a lower digestibility than either cottonseed meal or corn. There is no evidence to preclude the possibility that the char-

acter of the nitrogen absorbed from alfalfa hay differs qualitatively from that remaining in the undigested residues. Judging from the ease with which tyrosine is split off from proteins in tryptic digestion in vitro, it is possible that the absorbed nitrogen contains a greater proportion of amino acids essential to the body than the unabsorbed portion. Further, the sterochemical arrangement of the amino acids in the protein molecule may affect the extent to which the digestive enzymes are able to cause hydrolysis of the different proteins. A second consideration is the possible interchangeability of the various forms of nitrogen in nutrition, as already pointed out in the case of arginine and histidine. To what extent the nonprotein nitrogen of alfalfa hay is utilized in maintenance is problematical, but since there is no reason to doubt that the degradation products of crude protein are able to serve in this capacity, it is possible that a large part of the absorbed nonprotein nitrogen fulfills some of the requirements of the animal body.

It is reasonable to assign the higher content of the basic amino acids of cottonseed meal as the reason for its superiority over the proteins of alfalfa and corn. In the case of the last mentioned feedingstuff, there is the additional factor of a comparatively low lysine content to be considered, although from the studies of Osborne and Mendel concerning the lysine requirements for growth, a lysine content of 2.2 per cent of the protein appears to be ample for normal growth.

In the absence of further information respecting the character of the mono-amino acid and nonprotein nitrogen content of these feedingstuffs, a detailed picture of which the Van Slyke analysis does not include, correlations between the chemical composition and nutritive value of the proteins of feedingstuffs can proceed little beyond the realm of the functions and relationships of the basic amino acids.

Comparison of feed consumption with that of farm animals. It was noted during the course of this investigation that the rats consumed an enormous amount of feed in proportion to their live weights. In some few cases the amount of air dry feed eaten daily was equivalent to as much as 10 or 11 per cent of the

TABLE 9

Comparison of feed consumption by albino rats with that of farm animals

SPECIES OR BREED AND CLASS OF ANIMAL	LENGTH OF FEEDING PERIOD	FEEDS IN RATION	NUMBER OF ANIMALS FED	AVERAGE AGE	AVERAGE LIVE WEIGHT	FEED EATEN DAILY PER 100 POUNDS LIVE WEIGHT
	days			*days*	*pounds*	*pounds*
Percheron fillies*	28	Corn + oats + alfalfa hay	10	227	854	2.2
	28	Corn + oats + alfalfa hay	10	683	1484	1.8
Hereford steers†	35	Corn + linseed meal + clover hay	4		978	2.5
	28	Corn + linseed meal + clover hay	4		1466	1.5
Jersey heifers‡	30	Corn + bran + linseed oil meal + alfalfa hay	4	365	472	2.9
	90	Corn + bran + linseed oil meal + alfalfa hay	4	730	839	1.8
Holstein heifers‡ ..	30	Corn + bran + linseed oil meal + alfalfa hay	4	365	656	2.4
	90	Corn + bran + linseed oil meal + alfalfa hay	4	730	1112	1.8
Swine§........			174		38	6.0
			495		128	3.8
			105		320	2.4
Sheep**......					45	2.1
					127	1.1
Albino rats .	42	Cottonseed meal + corn + alfalfa hay + synthetic mixture	9		129††	8.4§§
	21 or more***	18 per cent protein	17		175 200††	4 6§§

* From Bul. 192, Ill. Agr. Exp. Sta.

† From Bul. 197, Ill. Agr. Exp. Sta. Data concerning "Full-feed lot."

‡ From Nebr. Agr. Exp. Sta. Unpublished manuscript. Data concerning "Heavy fed groups."

§ From Henry and Morrison, Feeds and Feeding, 15th ed. p. 569.

** Calculated from data of Weiske as quoted by Armsby, The Nutrition of Farm Animals, p. 432.

†† Grams.

§§ Grams per 100 grams live weight.

*** From Osborne and Mendel. Protein Minima for Maintenance. Jour. Biol. Chem., 1915, xxii, 241.

live weight. It seemed of interest to compare the feed consumption of albino rats with that of farm animals. Such a comparison is made in table 9. The tabulations of horses and cattle include in each case two entries of the same group of animals at different ages and weights. It is known that the horses and cattle were restricted in the amount of concentrates consumed but were offered roughage to practically the limit of their appetites. Hence a comparison of the feed consumption of these animals with that of the first group of rats, which were the ones concerned in this investigation, is warranted, but the data are indicative only. Data for the amount of feed consumed by the swine, sheep and second group of rats is not at hand.

It is evident from the data presented that the rat is a voracious eater, even when receiving rations comparable to those of farm animals. A rough approximation places the relative amounts of feed eaten by rats as about three times that of various breeds and classes of farm animals, if swine be excepted. The fact is also brought out, as has previously been noted by others, that the young animal consumes much more feed in proportion to live weight than when older and heavier.

Cottonseed meal probably not toxic to albino rats. None of the rations containing cottonseed meal seemed to exert any harmful influence upon the rats consuming it. Three of the animals received continuously for 7 weeks rations containing from 7.7 per cent to 23.9 per cent cottonseed meal with no evidence of toxic symptoms but remained in excellent nutritive condition. This observation is in agreement with those of Richardson and Green (1) and Osborne and Mendel (5).

SUMMARY OF THE DISCUSSION OF THE NUTRITIVE VALUE OF THE PROTEINS

Evidence is presented to show that metabolism experiments with the rat as a subject can be carried out with a high degree of accuracy.

Different methods of expressing the nutritive value of the proteins of feedingstuffs are discussed. The plan of employing the

results secured in a preliminary and final metabolism period during which the animal receives a nitrogen free ration, for the calculation of the percentage of the absorbed nitrogen utilized, is favored. In comparing the nutritive value of the combined proteins of the feedingstuffs cottonseed meal, alfalfa hay and corn, it was found that when one of these feeds furnished the sole source of protein in rations containing 10 per cent of crude protein, the utilization of the proteins for the growth of albino rats was, in the order in which the feedingstuffs are named, 66 per cent, 62 per cent and 49 per cent, respectively.

When rations containing these feedingstuffs, combined in various ways, but with each feed furnishing an equal amount of digestible protein, were fed, there was evident no clear cut supplementary effect of the proteins of one feed upon another, except in the case of the combination cottonseed meal and alfalfa hay, which showed a slight effect.

No symptoms of toxicity were noted as a result of feeding rations containing cottonseed meal over a period of seven weeks.

When suitable rations are provided, the albino rat consumes an enormous amount of feed in proportion to its live weight.

The writer desires to express his appreciation of the assistance of Dr. H. H. Mitchell in outlining the method used in this investigation and for many helpful suggestions. He is also indebted to Dr. H. S. Grindley for his encouragement and general supervision of the thesis problem.

APPENDIX TABLE 1

The utilization of the proteins of cottonseed meal, corn and alfalfa hay

RAT NUMBER	PERIOD	RATION	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CONSUMED	(a) DAILY INTAKE OF N	(b) DAILY URINARY N	(c) DAILY FECAL N	(d) METABOLIC N IN FECES	(e) ENDOGENOUS N	(f) ABSORBED N RETAINED	(g) UTILIZATION OF ABSORBED N‡	(h) ABSORBED N RETAINED	(i) DIGESTIBILITY: Ordinary coefficient	(j) DIGESTIBILITY: Corrected coefficient
			grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm*	*per cent*	*per cent*	*per cent*	*per cent*
1	2	Cottonseed meal	92	103	9.52	166.7	71.8	62.2	24.1	24.4	56.8	63	31	63	77
2	2		104	113	8.66	151.6	70.7	62.2	22.1	30.4	40.8	64	21	59	74
3	2		121	133	11.51	201.4	74.3	68.3	29.7	26.8	88.5	71	44	66	71
Average												66	32	63	74
1	3	Cottonseed meal	103	109	9.48	165.8	68.8	68.9	24.0	26.1	52.1	65	29	58	73
2	3		113	118	8.57	149.9	67.0	69.2	21.9	30.4	35.6	64	17	54	69
3	3		133	144	12.47	218.1	82.2	74.1	32.3	29.2	94.1	70	43	66	81
Average												66	30	59	74
1	4	Cottonseed meal + alfalfa hay	109	113	10.60	189.8	68.6	100.1	26.9	29.7	48.0	67	24	47	62
2	4		118	129	11.39	203.9	67.2	96.1	29.1	34.6	69.7	76	38	53	67
3	4		145	160	14.91	267.0	91.6	132.4	38.7	32.2	81.7	66	32	50	65
Average												70	31	50	65
1	5	Cottonseed meal + alfalfa hay	113	121	11.06	198.0	77.40	90.9	28.0	31.4	57.7	66	28	54	68
2	5		129	133	10.73	192.1	80.00	93.0	27.4	36.7	46.5	66	19	52	66
3	5		160	173	16.45	294.5	99.30	140.6	42.7	35.1	97.3	67	35	53	67
Average												66	27	53	67

1	6	N-free.	113	102	6 10		21 5	18.7							
2	6	Cottonseed meal +	134	137	10.13	180 5	79 8	78 1	25 8	37 9	48.4	67	22	57	71
3	6	alfalfa hay + corn	182	188	14 47	257.9	102 2	119 1	37 5	39 0	74 1	64	26	54	69
												66	24	56	70
Average								73 3†			42.7	67		57	71
2	7	Cottonseed meal +	137	138	9 51	169.4	77 7	(65 5)*	24 3	38 5	(50 5)	(69)	19	(61)	(76)
3	7	alfalfa hay + corn	188	189	13 54	241 3	98 8	106 8	35 1	39 8	70 8	65	27	56	70
Average												62	23	57	71
4	2	Corn	117	119	7.44	123.4	80 3	28 5	18.6	22.7	33 2	49	15	77	92
5	2		108	108	7 66	127 2	81 7	30 1	20 9	27 1	36 3	54	16	76	93
6	2		116	115	7.49	124.3	70 4	32 4	20 2	20 4	41 7	55	23	74	90
Average												53	18	76	92
4	3	Corn	119	119	8 05	133 6	88 3	29 5	20 2	22 8	36 0	47	15	78	93
5	3		108	107	6.30	104 6	80 8	28 0	17 2	27.0	13 0	43	—	73	90
6	3		115	113	6.35	105 3	70 4	25 6	17 2	20 2	26 5	48	9	76	92
Average												46	12	76	92
4	4	Corn and cottonseed	122	131	9 95	176 8	80 4	61.1	24 9	24.3	60 2	60	31	66	80
5	4	meal	110	115	8 56	152.0	80 0	52 4	23 3	28 2	42 9	58	20	66	81
6	4		116	128	8 48	150 8	76 2	49 6	22 9	21 6	47.9	56	25	67	82
Average												58	25	66	81
4	5	Corn and cottonseed	131	135	9 67	171 9	83 5	53 9	24 2	25 5	58 7	59	29	69	83
5	5	meal	115	125	8.04	142.8	78 5	42 0	21 9	30 1	44 2	61	22	71	86
6	5		128	132	7 73	137.4	66.4	42 0	20 9	23.0	49 9	63	30	69	85
Average												61	27	70	85

APPENDIX TABLE 1—*Continued*

RAT NUMBER	PERIOD	RATION	INITIAL WEIGHT	FINAL WEIGHT	DAILY FEED CON-SUMED	(a) DAILY IN-TAKE OF N	(b) DAILY URI-NARY N	(c) DAILY FECAL N	(d) META-BOLIC N IN FECES	(e) ENDO-GEN-OUS N	(f) AB-SORBED N RE-TAINED	(g) UTILI-ZATION OF AB-SORBED N‡	(h) AB-SORBED N RE-TAINED	(i) DIGESTIBILITY Ordi-nary coeffi-cient	(j) DIGESTIBILITY Cor-rected coeffi-cient
			grams	*grams*	*grams*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm*	*per cent*	*per cent*	*per cent*	*per cent*
4	6	N-free.	135	130	9 02		16 3	20 1							
5	6	Cottonseed meal +	134	139	11.03	196 6	88 5	92 2	30 1	34 3	46 1	60	15	53	68
6	6	corn + alfalfa	133	143	10 68	190.3	77 3	88.0	28.9	24 4	53 9	60	24	54	69
Average												60	20	54	69
5	7	Cottonseed meal +	139	144	10 77	191.9	86 8	82 1	29 4	35 5	52 4	63	21	57	73
6	7	corn + alfalfa	143	148	11.72	208 9	86 8	78 2	31 7	25 8	75 6	62	33	63	78
Average												63	27	60	76
7	2	Alfalfa hay	103	109	9.33	171.0	61.0	91.4	24 8	21 3	43 4	62	23	47	61
8	2		103	105	9.19	165.8	62.5	91 1	27.4	20 0	39 6	58	16	45	62
9	2		116	119	11.42	206.3	65.4	122 5	28.1	28.8	46.5	67	22	41	54
Average												62	20	44	59
7	3	Alfalfa hay	109	104	9.50	171 5	63 4	102 4	25.2	21.4	30 9	57	8	40	55
8	3		105	103	8.20	148 0	55.9	88 7	24 4	20 0	27 8	57	6	40	57
9	3		119	126	13 67	246.9	68 4	136.3	33 7	30.0	75.9	73	38	45	58
Average												62	17	42	57

7	4	Alfalfa hay + corn	107	117	12.86	219.6	95.1	105.3	34.2	22.5	53.4	51	17	52	68
8	4		106	125	14.82	253.1	105.8	111.9	44.2	22.2	79.6	55	25	56	73
9	4		127	132	12.18	208.0	94.5	79.6	30.0	31.7	63.9	60	26	62	76
Average												55	23	57	72
7	5	Alfalfa hay + corn	117	122	12.41	211.9	89.4	95.3	33.0	24.0	60.2	57	23	55	71
8	5		125	129	13.34	227.8	88.0	101.5	39.8	24.4	78.1	62	30	55	73
9	5		132	140	12.84	219.3	97.5	76.1	31.6	33.3	77.3	63	32	65	80
Average												61	28	58	75
7	6	N-free.	118	105	4.76		23.8	17.0							
8	6	Cottonseed meal +	134	141	12.06	214.9	93.2	96.0	36.0	26.4	61.7	57	22	55	72
9	6	corn + alfalfa	147	157	13.55	241.5	109.2	86.0	33.3	37.2	79.6	62	30	64	78
Average												60	26	60	75
8	7	Cottonseed meal +	141	147	11.55	205.8	82.0	90.1	34.4	27.6	68.3	64	29	56	73
9	7	corn + alfalfa	157	160	12.57	224.0	106.6	75.8	31.0	38.8	72.6	62	28	66	80
Average												63	29	61	78

Method of calculation:

1. $a - b - (c - d) = f$
2. $\dfrac{e + f}{a - (c - d)} \times 100 = g$
3. $\dfrac{a - c - b}{a - c} \times 100 = h$
4. $\dfrac{a - c}{a} \times 100 = i$
5. $\dfrac{a - (c - d)}{a} \times 100 = j$

* A loss occurred during Kjeldahl digestion of feces.

† Based on amount of fecal nitrogen per gram of feed in Period 6.

‡ As calculated for both maintenance and growth.

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DAIRY NOTES

J. W. HENDRICKSON

University of Nebraska, Lincoln, Nebraska

The following appointments and resignations are reported by the Dairy Division, United States Department of Agriculture:

Appointments

P. N. Peter, a graduate of Maryland State College, who has taken post-graduate work at Yale University, has been appointed for chemical research work in connection with dairy by-products. Mr. Peter was formerly employed in research work at the Picatinny Arsenal, Dover, N. J.

M. H. Fohrman, a graduate of the University of Missouri with a master's degree also from that institution, has been appointed to assist in the cattle breeding experiments conducted by the Dairy Division. Mr. Fohrman came from the University of Minnesota where he was employed as assistant professor of dairy husbandry and supt. of official testing.

W. E. Wintermeyer, a graduate of Pennsylvania State College, who for several years has been engaged in extension work, has been appointed to assist in the organization of bull associations.

Earle O. Whittier, a graduate of the University of Maine, with a master's degree from that institution, has been appointed for chemical research work on the utilization of dairy by-products. Mr. Whittier served as instructor in chemistry at Simmons College, and as research chemist with the E. I. du Pont De Nemours Company before coming to the Dairy Division.

Robert E. Hardell, a graduate of the University of Wisconsin, who specialized in dairy manufacturing, has been appointed for experimental cheese investigations in the Dairy Division.

Stanley Evans, a graduate of Ohio State University, who specialized in dairying, has been appointed for experimental cheese work at the Grove City (Pa.) laboratory of the Dairy Division.

L. S. Edwards, has been reappointed for creamery extension work in Mississippi and Louisiana.

Resignations

C. L. McArthur, who has been engaged in bacteriological investigations in the Dairy Division since 1918, has resigned to accept a position with the F. X. Baumert Cheese Co., Antwerp, New York.

H. F. Zoller, who has been engaged in chemical research work in the Dairy Division for the past four years, has resigned to accept a position with the Parke-Davis Co., Detroit, Mich.

Miss Louise G. Holbrook, who has been engaged in extension work in the greater utilization of milk, under the direction of Miss Jessie M. Hoover, has resigned, effective July 20, 1921.

E. H. Parfitt, who has been employed on cheese investigations for the past 15 months, has resigned to accept a position in dairy manufacturing at Purdue University.

Dr. H. A. Ruehe, head of the Department of Dairy Husbandry of Illinois has just returned to his duties after a year leave of absence in which he was pursuing work for his doctorate degree at Cornell.

Dr. W. B. Nevens, who was formerly in charge of dairy production work at the University of Nebraska has completed his graduate work and has also accepted the position of Assistant Professor of Dairy Nutrition at the University of Illinois.

Professor H. P. Davis formerly of the Dairy Department of Idaho University and of the Dairy Division at Washington, D. C., has accepted the position of Chairman of the Dairy Department at the University of Nebraska.

A recent number of the Journal has a list of instructors in most of the institutions in the United States.

The following list of instructors was reported for Illinois on August 12, 1921:

Dairy Department Staff, Urbana, Illinois

H. A. Ruehe, Ph.D., Professor Dairy Manufacturing, Head of Department

M. J. Prucha, Ph.D., Professor Dairy Bacteriology

W. J. Fraser, M.S., Professor Dairy Farming

W. L. Gaines, Ph.D., Professor Milk Production

W. W. Yapp, M.S., Assistant Professor Dairy Cattle
O. R. Overman, Ph.D., Assistant Professor Dairy Chemistry
A. S. Ambrose, B.S., Associate Dairy Manufacture
C. S. Rhode, B.S., Assistant Professor Dairy Husbandry Extension
H. A. Ross, B.S., Associate Dairy Economics
Mason H. Campbell, M.S., Associate Dairy Husbandry
R. W. Peterson, B.S., Associate Dairy Husbandry
B. A. Stiritz, B.S. Associate Dairy Manufacture
P. H. Tracy, B.S., Assistant Dairy Manufacture
W. B. Nevens, Ph.D., Assistant Professor Dairy Nutrition
F. P. Sanmann, B.S., Assistant Dairy Chemistry
H. F. Hall, B.S., Assistant Dairy Economics
F. A. Davidson, B.S., Assistant Dairy Husbandry
J. M. Brannon, Ph.D., Associate Dairy Bacteriology

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